Vol. 80 NOVEMBER-DECEMBER 1953 No. 6

UNIVERSITY OF MICHIGAN
JAN 8 1954
SCIENCE LIBRARY

Bulletin

of the

Torrey Botanical Club

CONTENTS

Variations in the Floral Morphology of Normal and Irradiated Plants Tradescantia paludosa
James E. Gunckel, Ielene B. Morrow, Arnold H. Sparrow and Eric Christensen 445

Developmental Anatomy of the Fruit of Prunus domestica L.
Clarence Sterling 457

The Racemose Vaucheriae with Inclined or Pendent Oogonia
John L. Blum 478

Notes on Two Smuts Reported from the United States
Marvin D. Whitehead and M. J. Thirumalachar 498

A New Meliosma from the Colombian Andes ..... *Julian A. Steyermark* 500

A Cytological Study of the Development of Galtonia candicans Decne
C. A. Berger and E. B. Witkus 501

Study of Trickling Filter Fungi ..... *C. W. Hesseltine* 507

Torreya 515
Millspaugh's Footsteps Retraced after Sixty-Nine Years. By J. Harry Lehr. Field Trip Reports. Book Reviews.

Index to American Botanical Literature 518

Index to Volume 80 530

Published for the Club bi-monthly
by
THE BUSINESS PRESS, INC.
N. QUEEN ST. AND McGOVERN AVE.
LANCASTER, PENNSYLVANIA

THE TORREY BOTANICAL CLUB

Officers for 1953

President: JENNIE L. S. SIMPSON

Vice-presidents: M. F. BUELL, CLYDE CHANDLER

Recording Secretary: DONALD P. ROGERS

Corresponding Secretary: ELEANOR R. WITKUS

Treasurer: ELVA LAWTON

Editor: CHARLES A. BERGER

Business Manager: GILY E. BARD

Bibliographer: MRS. LAZELLA SCHWARTEN

The Bulletin of the Torrey Botanical Club

Editor

Charles A. Berger

Associate Editors

Irving W. Bailey
Stanley A. Cain
Adriance S. Foster
Barbara McClintock
Murray F. Buell
Edwin B. Matzke
Wendell H. Camp
Donald P. Rogers
H. W. Rickett
Frederick Kavanagh

John A. Small (Torreya)

Membership dues should be sent to Dr. Elva Lawton, Hunter College New York 21, N. Y. Subscriptions and correspondence about advertisements and back numbers should be addressed to Dr. G. E. Bard, Botany Department, Hunter College, New York 21, N. Y. Communications about exchanges should be sent to Dr. E. R. Witkus, Biological Laboratory, Fordham University, New York 58, N. Y. Manuscripts intended for the Bulletin should be sent to Dr. C. A. Berger, Biological Laboratory, Fordham University, New York 58, N. Y. Material for Torreya should be sent to Dr. John A. Small, New Jersey College for Women, New Brunswick, N. J.

Claims for missing numbers must be made within 60 days from the date of issue. Changes of address of members should be set to the treasurer.

The subscription price of the Bulletin of the Torrey Botanical Club (including Torreya), is $9.00 a year except to active members of the Club. The annual membership dues covers a year's subscription to the Bulletin.

Entered as second-class matter October 8, 1940 at the post office at Lancaster, Pa., under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in Paragraph (d-2) Section 34.40 P. L. & R. of 1948.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, No. 6, pp. 445–456 NOVEMBER, 1953

VARIATIONS IN THE FLORAL MORPHOLOGY OF NORMAL AND IRRADIATED PLANTS OF TRADESCANTIA PALUDOSA.[1]

JAMES E. GUNCKEL,[2] IELENE B. MORROW, ARNOLD H. SPARROW, AND ERIC CHRISTENSEN

The flowers of *Tradescantia,* particularly of *T. paludosa,* have provided very favorable material for cyto-genetical studies. It was thought that it would be of interest and a base for experimental studies, therefore, to describe variations in the normal (non-irradiated) flowers of *T. paludosa* and to compare these with the aberrant floral development of irradiated plants. The gross effects described in the present study will be supplemented by detailed morphological and histological studies in later papers.

Materials and methods. The material used was the B2-2 clone of *Tradescantia paludosa* Anderson and Woodson which had been propagated by cuttings. Most of the plants used for irradiation studies grew from cuttings (with or without leaves) of the basal nodes of the primary axis, treated and untreated with rooting hormone. Cuttings from terminal nodes of primary or secondary shoots, including the involucral bracts and a few flower buds, produce plants which show a high degree of floral abnormality. Further details on cuttings may be found in Gunckel, Sparrow, Morrow and Christensen (1953). The plants were exposed to gamma irradiation from a 200 curie source of cobalt-60 by planting on concentric arcs at various distances from the source. Actual dose rates varied from 1.8 to 113 r per day. A detailed description of the apparatus and methods used for growing plants under continuous gamma irradiation is given by Sparrow and Singleton (1953).

Normal non-irradiated flowers. The inflorescence of *T. paludosa* terminates the axis and includes a stalk, two foliform bracts, and paired, sessile cymes. Only one flower stalk is formed at each node. Each half of the inflorescence produces a variable number of single flowers with associated bracteoles (fig. 1). The flowers alternate left and right in each half of the inflorescence with the central flowers blooming earliest (fig. 1, *c-2*). Ordinarily, one flower opens each day on one half of the inflorescence. However, those interested in following cytological stages very carefully should

[1] Sincere appreciation is extended to Mr. Frank K. German and his greenhouse staff at the Brookhaven National Laboratory for growing the plants used in this study.

[2] Research supported by contract no. AT (30-1)-1120 from the Atomic Energy Commission and with the cooperation of the Research Council, Rutgers University. A portion of the research was carried out at the Brookhaven National Laboratory, Upton, L. I., N. Y.

[THE BULLETIN for September–October, 1953 (80: 365–443) was issued October 15, 1953]

FIG. 1–5. Development of non-irradiated flower buds and inflorescences of *Tradescantia paludosa*. FIG. 1. Normal inflorescence with one bract removed to show all parts: the flower stalk (*fs*), the bract (*br*), the paired cymes (*c-1*, *c-2*) with associated bracteoles (*brl*). One cyme (*c-2*) shows the scorpioid arrangement of flower parts with the oldest bud at the center and successively younger buds alternating to left and right. After opening, the flower curves down and the rapidly enlarging ovary (*ov*) is surrounded by persistent and enlarged sepals. Additional flower buds (*fb*) continue to form at the base of the cyme. FIG. 2. Normal pentacyclic flower with 3 sepals (*se*), 3 petals (*pe*), 6 stamens (*sta*) with tufts of moniliform hairs (*mh*) at their base, and a central pistil (*p*). FIG. 3. Abnormal B2-2 flower with 3 sepals (*se*), 4 petals (*pe*), the fourth not

note a considerable variability in flower opening (table 1). Should more than one flower in an inflorescence open on any one day, then there will usually be a lag in the next flowering corresponding to the number of extra flowers produced. When flowers begin to open, the number of buds in each half of the inflorescence varies from about 12 for a terminal inflorescence to 6 for a lateral one. Since flowering continues in most heads for about two months, there is some indication of the number of additional flower buds that must be formed at the base of the inflorescence in the axil of each foliform bract (fig. 1, *fb*). Individual flowers are usually pentacyclic on a plan of three (fig. 2). Old flower heads commonly give rise to a variable number of new shoots. That is, after several months, the growth habit becomes procumbent (fig. 7) and heavy flower heads may then bend over and

TABLE 1. *Variability in the number and per cent of individual flowers of Tradescantia paludosa opening per day per inflorescence* when grown in the greenhouse, Brookhaven National Laboratory, Upton, L. I., N. Y.*

Date	Tot. No. Flowers Per Day	1 flower/head		2 flowers/head		3 flowers/head	
		No.	%	No.	%	No.	%
Aug. 15, 1952	134	110	82.1	22	16.4	2	1.5
Aug. 18, 1952	168	158	94.05	10	5.95	.....	.....
Aug. 19, 1952	196	167	85.2	29	14.8	.....	.....
Aug. 20, 1952	220	200	90.9	20	9.1	.....	.....
Aug. 21, 1952	248	216	87.1	32	12.9	.....	.....
Total	966	851	88.1	113	11.7	2	0.2

* Data are for both terminal and lateral inflorescences. The rapid increase in the total number of flowers per day can be attributed to the increasing number of lateral inflorescences coming into flower.

make contact with the soil. In this case, the shoots formed on the old inflorescence take root and form individual plantlets (fig. 4). Further details of flowering are described in another paper in the series (Gunckel, Sparrow, Morrow and Christensen, 1953).

Aberrant non-irradiated flowers. Abnormal development of B2-2 stock occurs to a marked degree on plants that grow from cuttings which are making or have made very poor vegetative growth. For example, of the two plants grown from terminal cuttings and shown in figure 5, the plant on

complete and with anther tissue (*an*) on the margin, 2 stamens (*sta*), and a pistil (*p*). FIG. 4. Old flower head (*fh*) on procumbent plant has formed a number of new shoots (*sh*) which form roots (*r*), and become independent plantlets. A persistent flower in the lower right shows the characteristic persistent, enlarged sepals (*se*). FIG. 5. A shortened primary stem (*ps*) produced aberrant flowers and then three secondary shoots (*ss-1-3*). The first two secondary shoots make normal vegetative growth but terminate in a head of modified leaves (*lfh*). The third is foreshortened, producing only a bract in the axil of which formed two modified sepals, one bearing a mass of anther-like tissue (*an*) fused to one margin.

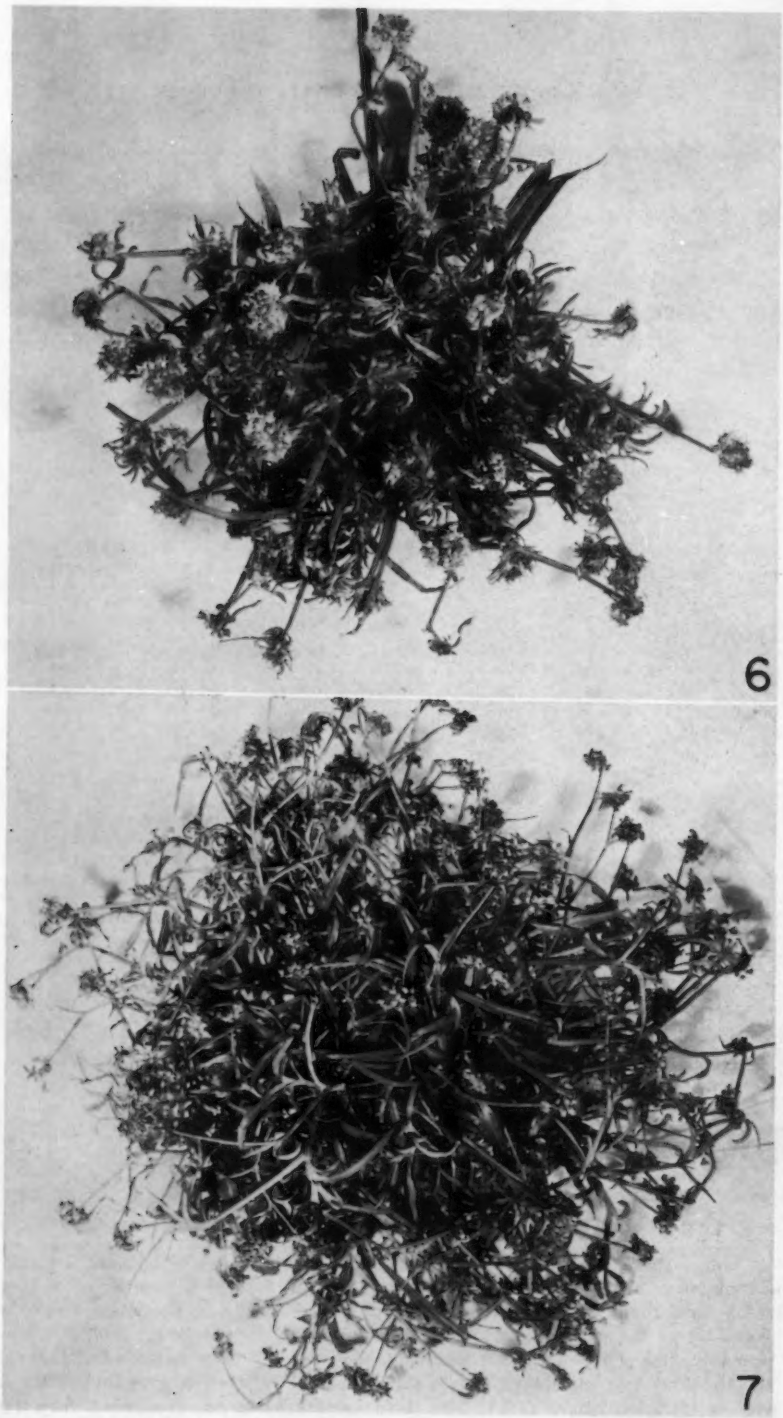


FIG. 6. Habit shot of plants irradiated at 30 r per day for about five months. Note large, globose, flower-like heads of modified leaves. The shoots are stunted, erect, little branched. FIG. 7. Habit shot of plant irradiated at 2.9 r per day for about five months. At the lower dosage, the plants are taller but procumbent, much branched, and each shoot terminates in an inflorescence that is not overgrown, but the individual flowers have missing, extra, or modified flower parts rather frequently.

the right illustrates this point. The primary shoot (*ps*) grew only a few inches and produced a limited number of flowers which show irregularity of flower parts. From this primary flower head grew three secondary shoots. The first (*ss-1*) and second (*ss-2*) shoots elongated in normal vegetative fashion, but the flower heads, as common in such cases, form a terminal structure which closely resembles a flower cluster but is actually a head of chlorotic leaf whorls (*lfh*). The third shoot (*ss-3*) growing from the old inflorescence shows, in the axil of a single floral bract (*br*), a pair of modified sepals (*se*) and fused to them a chlorotic mass of modified anther tissue (*an*).

Individual flowers in an inflorescence show a wide range of variability. Sepals are normally three in number but two sepals separate or fused to a modified petal occur rarely. Also, particularly in old flowers, the sepals may elongate sufficiently to appear leaf-like (fig. 4, 5, *se*). Petal number varies from 2–5, three being the usual number. The extra petals are usually not entire, but occur as irregular flaps of tissue with anthers attached to the midvein or margin (fig. 3). The stamens ordinarily occur in two whorls of three but are more variable than any of the other flower parts. In addition to the stamen filament being absent or fused to a petal, or the anther sac fused to a sepal (fig. 5), petal (fig. 3) or pistil, the stamens are very commonly reduced in number (fig. 3 *sta*). The percentage of stamen and petal variations may vary from time to time. However, out of 196 flowers observed on August 19 (Table 1) about 8 per cent were abnormal. This seems a reasonably accurate index of variability since it was confirmed by dissection of all the flower buds on a number of inflorescences collected throughout the growing season. No variations have been noted in the pistil other than one or two cases among the hundreds observed where there is a slight lack of fusion of the carpels.

Irradiated flowers. At the time of transplantation to the "gamma" field, dissection of a few plants showed the terminal and lateral buds to be just at the flowering stage. We shall confine ourselves to the terminal inflorescences since the lateral buds go through essentially the same developmental cycle but are retarded until the terminal inhibition is removed by irradiation damage to, or flowering of, the terminal head.

Flower heads at the high dosage levels (54–113 r per day) stop growing within a week after irradiation, individual flowers die after 3–4 wks., and whole inflorescences are dead by 8 wks. (fig. 8). The number of dead flowers is indicative of the fact that no new flower buds are formed after irradiation.

Plants in the rows receiving less than 54 r per day all show proliferation of flower buds. Development of the buds, however, depends upon the level of daily dosages. After about 8 wks., flower buds of the terminal in-

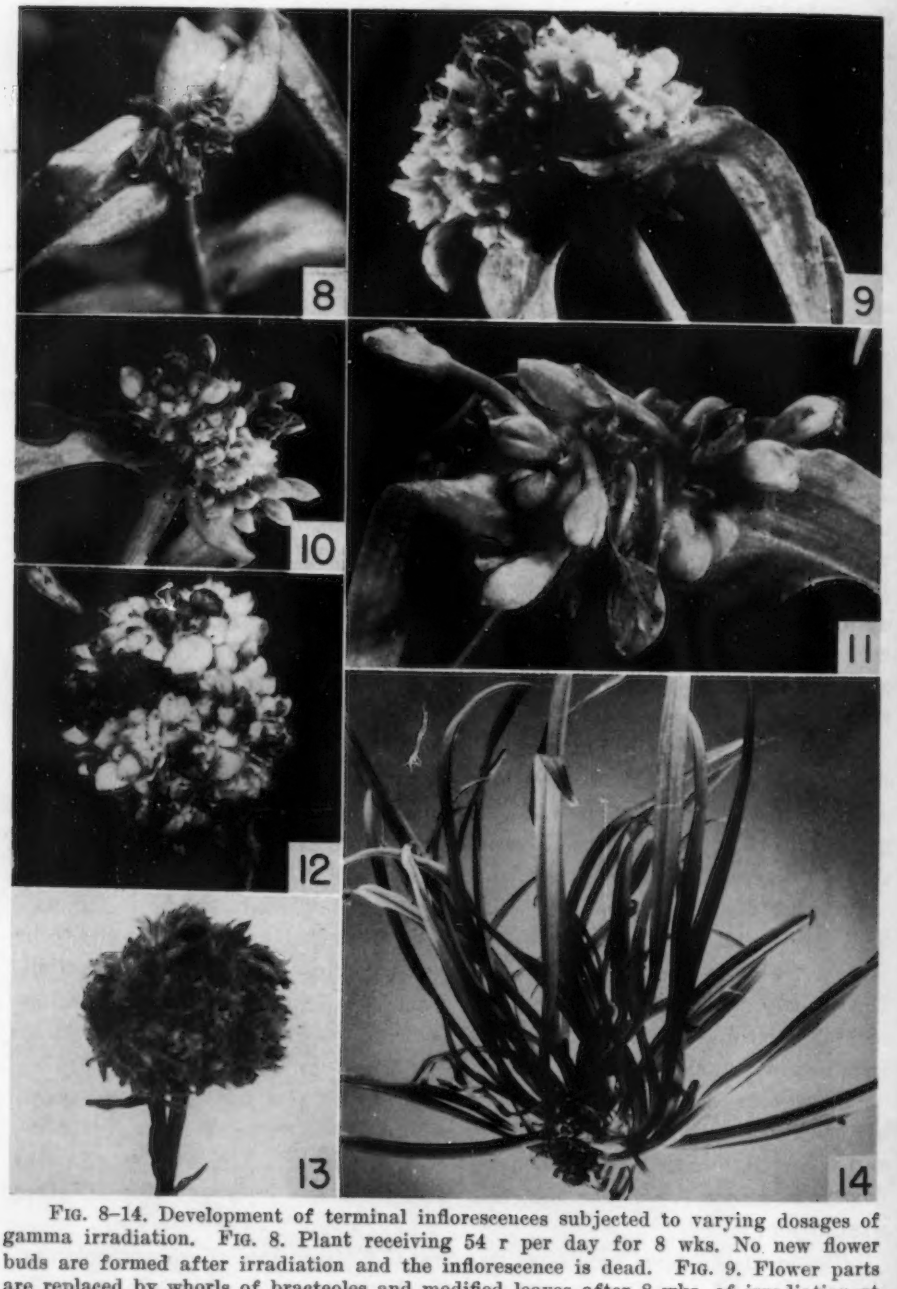


FIG. 8–14. Development of terminal inflorescences subjected to varying dosages of gamma irradiation. FIG. 8. Plant receiving 54 r per day for 8 wks. No new flower buds are formed after irradiation and the inflorescence is dead. FIG. 9. Flower parts are replaced by whorls of bracteoles and modified leaves after 8 wks. of irradiation at 29 r per day. FIG. 10. Inflorescence which received 23 r per day is proliferated by a mixture of whorls of modified leaves and of flower buds, most of which do not open

florescences in the rows receiving 29 r and 37 r per day have doubled in number and these later-formed buds give rise to whorls of modified leaves whose general configuration before enlargement suggests flower-like clusters (fig. 9). By the end of a full growing season (about 4–5 months of irradiation), these modified leaf clusters have proliferated and enlarged to form large globose heads. On close examination it can be seen (fig. 13) that the flower-like heads represent dark clusters of old flowers overgrown by whorls of fused and dissected leaf structures. Each leaf cluster originates from an adventitious bud arising from the parenchyma tissue of the old inflorescence. The growth habit of plants in this dosage range is more erect and much less branched than in normal plants since the lateral buds are fasciated and their growth inhibited (fig. 6).

Those inflorescences receiving 23–13 r per day are the most variable in the gamma field. Flower heads at the higher dosages (23–20 r per day) in this range show, after 8 wks., proliferation by a mixture of modified leaf whorls in floral positions followed by true flowers. Many of the flowers formed are sterile and do not usually open, or are abnormal in the number of flower parts of individual flowers, particularly petals and stamens (fig. 10). With longer irradiation time, usually about three months, more true flower buds are formed, although largely sterile, so that the leafy clusters are overgrown, and a globose flower head some 3–5 cm. in diameter results (fig. 12). Despite the number of flower buds in the inflorescence, only a few flowers open and these are quite irregular in the number and form of flower parts as described for aberrant non-irradiated flowers. Removed from the gamma field and brought into the greenhouse at the end of the growing season, these globose flower heads commonly generate a large number of vegetative shoots (fig. 14) much like those in the non-irradiated plants (fig. 4) but much more numerous. With decreasing dosage in this range, the number of flower buds initiated progressively decreases, but fewer of the flowers which do form are sterile. The number of flowers which open daily increases when compared with the number opening in the higher

---

or are slightly abnormal in numbers of flower parts. FIG. 11. At low dosages (7.9 r per day for 8 wks.) new basal flower buds are formed, much as in non-irradiated plants, except that bud arrangement is irregular rather than scorpioid and the flowers have extra, missing or modified parts. FIG. 12. Globose head resulting after about 5 months of irradiation. The inflorescence is a later stage to that shown in fig. 10. In a dosage range of 20–23 r per day, inflorescences show a mixture of modified leaves and aberrant flowers, with the latter predominating with increasing radiation time. FIG. 13. Proliferation of inflorescence by modified leaf whorls in flower positions. This head received 30 r per day for 4 months and is a later stage of development to that shown in fig. 9. FIG. 14. Old globose flower head, similar to that in fig. 12, has produced a large number of vegetative shoots about three months after removal from the gamma field. This is similar to the situation in non-irradiated plants (fig. 4) except that more inflorescences produce more shoots after irradiation.

dosages (23–20 r per day), and irregularities appear in the form and number of flower parts, particularly of petals and stamens.

Flowers in the rows receiving low dosages (1.8–7.9 r per day) form new flower buds similar to those of the non-irradiated plants except that the arrangement of flower buds is usually irregular rather than scorpioid (fig. 11). Also in this range, the flower buds invariably open and usually show extra, missing, or modified flower parts. About five per cent of the flowers on 196 inflorescences show two rather than three sepals on individual flowers and fusion between sepals and petals. As in the controls, the pistils are quite stable. Only occasionally is there evidence of lack of fusion between carpels, failure of the style to develop, or failure of a carpel to develop. The number and form of the petals and stamens vary widely in this range (nearly 95 per cent of all abnormalities observed). Flowers with two petals may be observed, but if the normal three are not present one finds usually an extra flap of petal tissue, commonly with a whole or half anther sac attached. These variations are not morphologically different from those observed in the control B2-2 stock (fig. 3), but they are quantitatively different since floral abnormalities occur in every inflorescence as compared with about eight per cent in the controls. The growth habit of plants in this dosage range is procumbent and much branched (fig. 7). Usually the most terminal two or three axillary buds form shoots which terminate in an inflorescence.

Discussion. The development of floral parts in *Tradescantia* has been described by Geleznoff (1843), Payer (1857), and Gravis (1898) and floral taxonomy by Anderson and Diehl (1932), Anderson and Woodson (1935), and Woodson (1942). The present investigation confirms the above accounts of inflorescences in which most individual flowers are pentacyclic on a plan of three. However, it is of some interest to point out the observed floral abnormalities which occur rather frequently.

Masters (1869) in his book on vegetable teratology noted that *Tradescantia* has a very marked tendency for augmentation of parts. Specific abnormalities included: stem fusion, the substitution of leaves for involucral bracts, apetaly, increase in the number of petals or perianth segments, petalody of the stamens, extra carpels, and double flowers. These abnormalities are given a complete and informative treatment in the book so will not be elaborated here. Not all of these abnormalities have been observed for *T. paludosa*. Gravis (1898) described anomalies in the inflorescence of a plant identified as *T. virginica* L., such as the existence of three floral bracts and three cymes in place of two, the atrophy of one of the bracts, and the replacement of a cyme by a leafy growth. Further, Shoop (1937) reported considerable fluctuation in the number of sepals, petals, and stamens in the flowers of *T. ozarkana*, although she observed none in

T. virginiana and *T. subaspera*. Singh (1948) in the egg plant, *Solanum Melongena*, observed fusion of flower parts in healthy plants, while unhealthy plans showed a "leafy" proliferation of flower parts. No direct explanation of these floral abnormalities was advanced. It seems probable, however, that abnormal flower development, as shown by our experience with cuttings of *Tradescantia* is associated with abnormal vegetative development.

In our irradiation experiments, the morphological effects were quantitatively but not qualitatively different from those in the abnormal, non-irradiated plants. That is, in those irradiated inflorescences which produced open flowers, all inflorescences showed some abnormality as compared with 8 per cent floral abnormalities in non-irradiated plants. Further, the changes can not be ascribed to cytogenetic effects but are considered to be physiological effects induced by the irradiation, since cuttings from these irradiated plants will eventually revert to a normal growth pattern. It thus seems plausible that the abnormalities observed in both irradiated and non-irradiated plants may be the result of the same or similar physiological changes. Irradiation studies coupled with nutritional studies would thus seem to afford an effective tool for analyzing some fundamental developmental processes.

The retardation or reduction and irregularities of flower development following irradiation have been described by several workers, particularly by Johnson (1926, 1931, 1936a and b, 1939). In general, the effects of gamma irradiation are comparable to the x-ray effects reviewed by Johnson (1936a) except that there is a strong indication that flowering may be stimulated in a few plants at relatively low gamma dosages. The number of flower buds formed is not altered appreciably but the flowers open much earlier than the controls or the other irradiated plants. This would agree with the findings of Haskins and Moore (1935) on x-rayed seeds of grapefruit. The temperature, light, water, soil, and nutrient factors were reasonably constant for all dosages so flower stimulation is probably a real effect, but will be checked more accurately by further work.

The level of daily dosages and not the cumulative dosage is the significant factor in our studies, on the basis of morphological responses. Thus, after six weeks of irradiation, plants receiving 29 r per day have formed a number of terminal bud primordia in floral positions which form only modified leaves. Inhibition of stem elongation and of axillary bud development is quite evident. Plants receiving 2.9 r per day for the same period appear normal in all respects. At a dosage of 29 r per day buds continue to form on the inflorescence until, after about two months, a globose head of mixed normal and sterile flowers results, but branching is scanty (fig. 7). A plant receiving 2.9 r per day for the same 8 wk. period is profusely branched and,

although the arrangement of flowers in the head is irregular, the number of flower buds in an inflorescence is not greatly increased (fig. 6). The individual flowers, however, have extra or missing members, principally in the petal and anther whorls. Further exposures at these two dosages will produce no further developmental changes. Experience has shown that if no effects appear by 4–5 months no new effects will appear with longer exposures. The relative importance of the level of daily dosages as contrasted with the cumulative ones has been pointed out in previous studies (Sax 1951, Sparrow & Singleton 1953).

The dose-response relationship suggests either that different enzyme systems have different levels of radiation sensitivity (see references and detailed discussion in Nickson 1952, Sparrow and Rubin 1952), or that a different mechanism is involved in different dosage ranges. Quastler and Baer (1948) suggests that different cytological and biochemical mechanisms may account for different radiation responses in different dosage ranges. These suggestions seem entirely reasonable, and the experimental evidence strongly suggests that, in *Tradescantia*, the radiation induced morphological abnormalities result from physiological or biochemical disturbances to one or more of the more sensitive systems.

SUMMARY

1. Gross aspects of the floral development in both irradiated and non-irradiated plants of *Tradescantia paludosa* are described.

2. The normal inflorescence is an umbellate cyme and the individual flowers are pentacyclic in a plan of three following the description of Anderson and Woodson (1935)

3. Variability in flowering and abnormal development of flower parts was noted in about 8 per cent of the inflorescences on non-irradiated plants, particularly in those making poor vegetative growth.

4. Plants exposed to chronic gamma irradiation from cobalt-^{60} for periods up to five months show varying responses depending upon the level of daily dosage.

5. Flower heads at the high dosage levels (113–54 r per day) are nearly completely inhibited in development and die after about 8 wks.

6. At the highest levels in the medium dosage range (37–29 r per day), lateral buds are suppressed and the inflorescence is first overgrown by clusters of modified leaves, later by true flowers, most of which are sterile and do not open. Overgrowth results in large globose flower heads which, when removed from the gamma field, later produce a large number of vegetative shoots.

7. With decreasing dosages (23–13 r per day) the total number of flower buds progressively decreases but only a few of the buds are sterile.

The number of flower parts, particularly petals or stamens, is somewhat variable.

8. The number of flower buds formed in the rows receiving low dosages (7.9–1.8 r per day) is comparable to that formed on non-irradiated plants, but the arrangement of buds is usually irregular rather than scorpioid. Every inflorescence shows a large number of individual flowers with extra, missing, or modified flower parts.

9. The morphological abnormalities are quantitatively but not qualitatively different from those found in the abnormal, non-irradiated plants.

Department of Botany, Rutgers University
New Brunswick, N. J.
Biology Department, Brookhaven National Laboratory
Upton, L. I., N. Y.

Literature Cited

Anderson, E. & Diehl, D. S. 1932. Contributions to the *Tradescantia* problem. Jour. Arnold Arb. **13**: 213–231.

Anderson, E. & Woodson, R. E. 1935. Species of *Tradescantia* indigenous to the U.S.A. Contr. Arnold Arb. **9**: 1–132.

Geleznoff, N. I. 1843. La génération et le développement de la fleur du *Tradescantia virginica*. Bull. Soc. Naturalistes Moscou **16**: 19–50.

Gravis, A. 1898. Recherches anatomiques et physiologiques sur le *Tradescantia virginica* L. au point de vue de l'organisation générale des Monocotylées et du type Commelinées en particular. Acad. Roy. Belg. Mem. Cour. Mem. Sav. Etrang. Brussels **57**: 1–304.

Gunckel, J. E., Sparrow, A. H., Morrow, Ielene B. & Christensen, E. 1953. Vegetative and floral development of irradiated and non-irradiated plants of *Tradescantia paludosa*. Amer. Jour. Bot. **40**: 317–332.

Haskins, C. P. & Moore, C. N. 1935. Growth modifications in *Citrus* seedlings grown from X-rayed seed. Plant Physiol. **10**: 179–185.

Johnson, Edna L. 1926. Effects of x-rays upon growth development and oxidizing enzymes of *Helianthus annuus*. Bot. Gaz. **82**: 373–402.

———. 1931. Effect of x-radiation upon growth and reproduction of tomato. Plant Physiol. **6**: 685–694.

———. 1936a. Effects of x-rays upon green plants. In B. M. Duggar ed. Biological Effects of Radiation. New York and London.

———. 1936b. Susceptibility of seventy species of flowering plants to x-radiation. Plant Physiol. **11**: 319–342.

———. 1939. Floral development of certain species as influenced by x-radiation of buds. Plant Physiol. **14**: 783–795.

Masters, M. T. 1869. Vegetable teratology, an account of the principal deviations from the usual construction of plants. Published for the Ray Society by Robert Hardwicke, London.

Nickson, J. J., ed. 1952. Symposium on Radiobiology. The basic aspects of radiation effects on living systems. New York and London.

Payer, J. B. 1857. Traité d'organogénie comparée de la fleur. Paris.

Quastler, H. & Baer, Marianne 1948. Inhibition of plant growth by irradiation. I. Discrete steps of inhibition and pattern of dose-response relation. J. Cell. Comp. Physiol. **31**: 213–234.

Sax, K. 1951. The cytological effects of low-intensity radiation. Science **112**: 332–333.

Shoop, Cora. 1937. Irregularities in the floral parts of *Tradescantia ozarkana*. Rhodora **39**: 46–49.

Singh, Harbhajan. 1948. Floral abnormalities in the brinjal, *Solanum Melongena* L. Jour. Indian Bot. Soc. **27**: 21–25.

Sparrow, A. H. & Rubin, B. A. 1952. Effects of radiations on biological systems. Survey Biol. Progress **2**: 1–52.

Sparrow, A. H. & Singleton, W. R. 1953. The use of radiocobalt as a source of gamma rays and some effects of chronic irradiation on growing plants. Amer. Nat. **87**: 29–48.

Woodson, Robert E. 1942. Commentary on the North American genera of Commelinaceae. Ann. Mo. Bot. Gard. **29**: 141–154.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, No. 6, pp. 457–477 NOVEMBER, 1953

DEVELOPMENTAL ANATOMY OF THE FRUIT OF *PRUNUS DOMESTICA* L.[1, 2]

CLARENCE STERLING

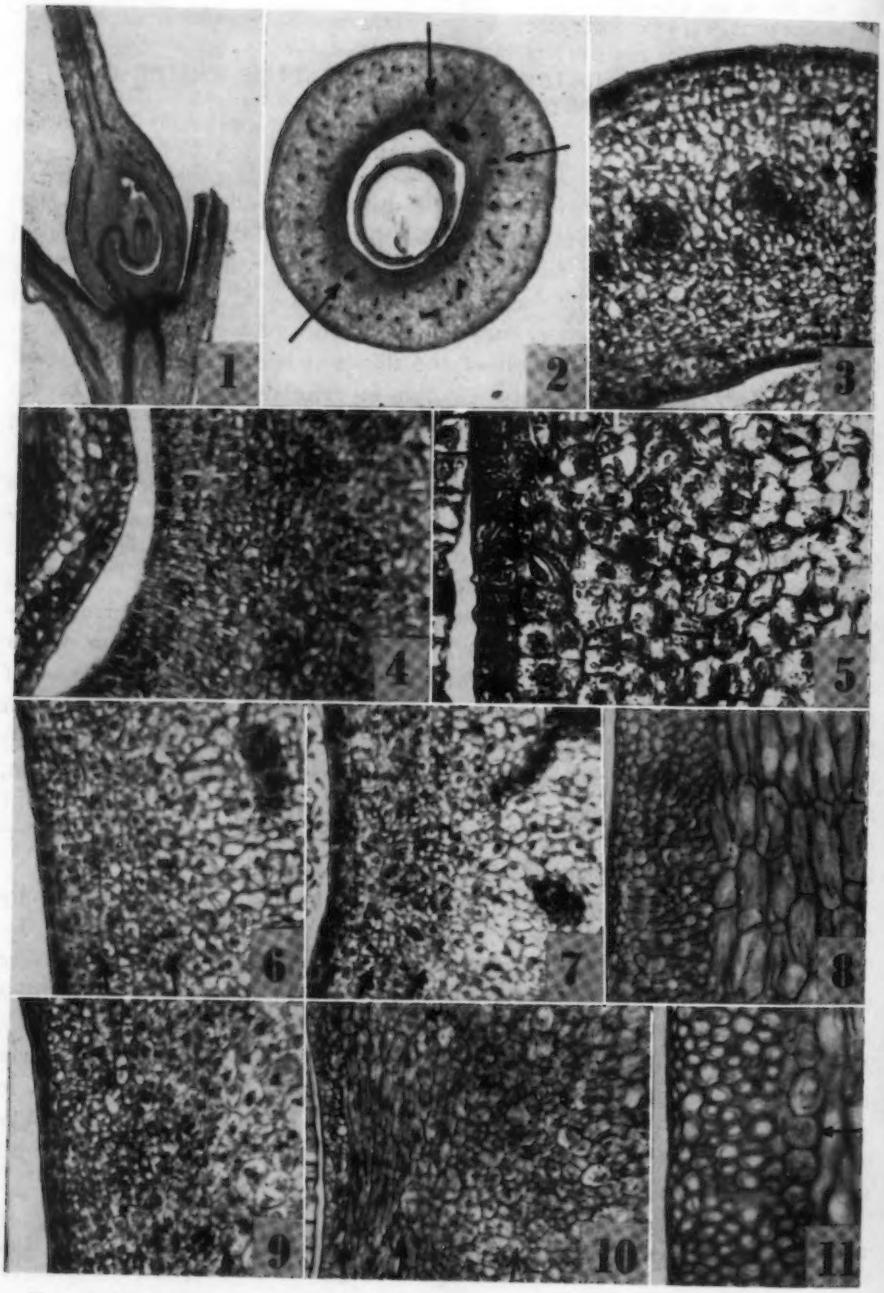
The present investigation deals with histogenetic development in the ovary of the prune subsequent to flowering. Anatomical data thus considered provide basic information for the definition of the various regions in a drupaceous fruit, *e.g.*, "skin," and "pit," and their equivalence in different species of *Prunus*. Since many ontogenetic studies of the ovary have been followed only up to development of the flower, which Croizat (1947) envisages as "an embryonal structure," data on fruit development are useful in a morphological interpretation of the fruit and the carpel(s) from which it develops.

Comparative structure and development of the Prunoidean drupe was first described by Cave (1869), whose work was dominated by an extremely literal concept of the foliar nature of the carpel, as was the later study of Garcin (1890). The former's description of a "zone génératrice" between mesocarp and the internal epidermal tissues has not been confirmed by Lampe (1886), Bordzilowski (1888), nor any subsequent investigator. Other observers have studied details of fruit organization in individual species of *Prunus* or in restricted portions of the fruit. The development of the peach fruit has been traced by Addoms, Nightingale and Blake (1930) and Ragland (1934). However, these studies give little attention to tissue derivation, and Harrold's (1935) investigation deals principally with the development of the seed of the peach. Tukey and Young (1939) have provided a detailed histogenetic account of fruit development in *P. cerasus*.

Fruit ontogeny in related genera of the Rosaceae was considered by Tschierske (1886) among the Dryadeae, by Farmer (1889) in *Rubus*, by Tukey and Young (1942) in apple, and by Mitchell (1950) in pear. Data on vascularization in rosacean carpels have been brought forth by the studies of Tieghem (1868), Tschierske (1886), Juel (1918), Saunders (1927), Bonne (1928), and Chute (1930). Structure of the skin of the fruit was investigated in peach by Dorsey and Potter (1932) and Miličić (1949), in plum by Valleau (1915) and Curtis (1928), and in pomoids by Zschokke (1897). Garcin (1891) is responsible for a comprehensive analysis of pit structure and development in drupes.

[1] The author is pleased to acknowledge the substantial assistance of Mrs. S. J. M. Loomis in the preparation of the slides used in the investigation. Dr. Katherine Esau has been kind enough to read the manuscript critically, for which appreciation is hereby expressed.

[2] Illustrations published with the assistance of the Lucien M. Underwood Memorial Fund.



FIGS. 1–11. All figures are of the French prune, except where noted. FIG. 1. Longisection of ovary at anthesis. Ovular strand runs directly to its ovule. A branch of the

Material and methods. Prunes of the French and Imperial varieties were obtained from trees in the Brynteson orchard near Campbell in Santa Clara county, California. Collections were made at biweekly intervals from the time of flowering through fruit abscission over a period of 22 weeks in 1951. Material was preserved in FAA and Craf III (Sass 1940). Dehydration was performed by a graded ethyl alcohol and xylene series for embedding in paraffin. After being cut at 10 or 15 μ, sections were stained with tannic acid-ferric chloride and safranin or with Conant's quadruple stain (Conant 1950).

Ovary structure at anthesis. Except for slight differences in detail, both prune varieties develop essentially in a similar manner. Hence the following description of the French prune will apply to both, save where noted.

The uniloculate ovary is attached basally to the receptacle within the cup-like floral tube (fig. 1). At the time of flowering, fusion of the sutural margins is complete. Below the funiculi, the visible line of this marginal union extends from a point between the ovular bundles to within several cells of the outer epidermis. At the level of the funiculi and up towards the style, the line of fusion is discernible from the inner epidermis (at the locule) to within a few cells of the outer epidermis (fig. 29). In no case is there an air space between the two margins; the latter are pressed tightly together. Where the juncture has not brought equivalent tissues together, the radial displacement of the margins is evident in a definite surface irregularity in the suture region, resulting in a much deeper cleft than normal.

ovular bundle is directed toward the style. × 13. FIG. 2. Transection of ovary 2 weeks after full bloom. Note early definition of pit region. Arrows indicate two wing bundles at upper right and dorsal bundle at lower left. The two large ovular bundles lie together at the suture. × 13. FIG. 3. Cross section of lateral ovary wall of Imperial prune at flowering. Locule is at base of photo. The inner epidermis, outer epidermis, and the respective layer immediately adjoining each are uniseriate. × 171. FIG. 4. Longisection of ovary of flower in region of ovular bundles. Locule is at left. × 171. FIG. 5. Cross section of inner part of ovary of flower. Periclinal divisions are just being initiated in inner epidermis at left and in the adjacent layer. The following 2–4 layers will form the outer portion of the pit. × 440. FIG. 6. Longisection of inner portion of ovary wall in advanced stage of flowering. Periclinally divided cells of inner epidermis at left are beginning to elongate. Arrows here, as in figures 7, 9 and 10 mark outer limits of each histogenic layer of pit. × 171. FIG. 7. Cross section of inner portion of ovary wall in advanced stage of flowering. Periclinal divisions being initiated in second pit histogen. Third histogen distinct from flesh cells by smaller size. × 171. FIG. 8. Cross section of inner portion of pit at 6 weeks, at cessation of cell divisions in this region. Cells derived from inner epidermis at left are elongated perpendicular to plane of section. Tangentially elongated cells at right are produced by second histogen. × 171. FIG. 9. Longisection in pit region at 2 weeks. Derivatives of inner epidermis are longitudinally elongated. Cells of second layer are small and isodiametric here. × 171. FIG. 10. Cross section in pit region at 2 weeks. Note elongation of cells of second layer in transverse plane. × 171. FIG. 11. Cross section at inner edge of pit at 8 weeks. Lignification of the cell walls has been initiated at the middle lamellae. Arrow indicates a strand of crystalliferous cells. × 171.

As is true of the ovaries of all prunoids and of many Rosaceae, two anatropous (campylotropous?) ovules, with their micropyles directed toward the style, are attached about halfway up the ovary. Later, greater growth of the ovary below the funiculi brings the point of attachment relatively much higher in the locule, as Ragland (1934) has also shown in peach. At the time of anthesis, the ovules may be found in stages ranging from that of the megasporocyte to stages in the formation of the cellular gametophyte. As is well-known among many other members of the family, one of the ovules generally disintegrates soon after flowering.

Each ovule is attached to one of the two sutural margins and is supplied by its own massive bundle from the vascular cylinder at the base of the ovary (fig. 29). The two ovular bundles, which are closely-adjoining, are accompanied up from the base for a short distance by a mass of procambial tissue which extends inwardly into the "pith," but ends below the base of the locule. Although Saunders (1927) and Bonne (1928) have described this tissue as medullary phloem, the writer has found short, irregularly-shaped tracheids of the so-called "wound tracheid" type scattered in this region during later development. One or two bundles branch from each ovular bundle in the base of the ovary and extend vertically with the latter for a short distance before passing outward. The main ovular bundles reach only to the level of the funiculi, passing into these latter and then down to the chalazal regions of the respective ovules (fig. 1).

From the vascular cylinder, three other large bundles pass upward through the ovary and into the style (figs. 2, 29). One of these, the so-called "dorsal bundle" is diametrically opposite to the ovular bundles. It passes close to the locule in its upward course. The other two bundles adjoin the ovular bundles, one on each side of the latter pair, lying between the ovular bundles and the dorsal bundle along the arc of a cylinder connecting these. These two bundles, called "wing bundles" by Saunders (1927), are not equivalent to the ventral bundles of the other authors (although they have been so designated by Tukey and Young 1939) since they have no connection with the ovular supply; they pass near the ovarian cavity and continue upwards into the style.

The other strands in the vascular cylinder at the base of the ovary pass upward more or less equidistant from each other and about seven or eight cells in from the outer epidermis. They furnish the main vascular supply of the developing fruit. They branch profusely in tangential and radial planes, and many of the branches anastomose, some with branches of the wing bundles. The majority of the bundles are still procambial, but others, like the ovular, dorsal, and wing bundles, already have a few differentiated tracheary and sieve elements. At flowering, branching, extension, and anastomosis of procambial strands are active, procambial extension and differen-

tiation being effected by divisions, parallel to the course of the strand, in adjacent cells.

The other ovarian tissues are also actively meristematic. The cytoplasm of both inner and outer epidermis stains deeply, and mitotic figures are numerous in these as well as in the intervening tissues. On the lateral faces of the ovary ("cheeks"), the inner epidermis is a single layer of cells of the eumeristem type. Divisions are mainly anticlinal, but some periclinal divisions occur (figs. 3, 5). Next is a layer, divided in two occasionally, of cells which are larger and have larger vacuoles. Division activity takes place as in the inner epidermis. External to this layer is a poorly-defined zone of 2–4 layers of cells with interstitial thickenings and large vacuoles. Divisions here occur in all planes. These latter cells constitute the outer part of the tissues which will become the hard "pit" or "stone" of the fruit (fig. 5). In the region of the dorsal bundle, the inner epidermis is followed by 2–3 rows of cells in the second layer and then a 5–6 celled zone of less active cells of the third layer. The third layer extends radially on both sides of the dorsal bundle but does not surround it. At the ovular bundles, there are 6–8 layers of cells between those bundles and the inner epidermis. The inner epidermis is relatively inactive here as are also the adjacent large, isodiametric cells of the second layer. The third layer extends out and around the ovular bundles and a portion of their branches. The wing bundles lie along the outer limit of the third layer, in a sulcus of this layer. In longisection, definite plate meristem activity can be noted in the inner epidermis and the two following zones in the vicinity of the ovular bundles (fig. 4). Mitotic activity here is so rapid that the cells are extremely flat and tabular, whereas they are isodiametric in other areas in all three layers. These layers may be considered as "histogens" since each gives rise to a specific tissue region in the pit.

The next outer 10–14 layers of cells, which enclose the bulk of the vascular strands, are composed of more or less vacuolate, isodiametric cells which divide in all planes (fig. 3). They will develop into the flesh of the mature fruit. These are followed by two layers of hypodermal cells, in which some periclinal divisions are being initiated, although anticlinal divisions are predominant (fig. 17). There are thickened deposits of intercellular material at the interstices of these cells. Some cells of the inner of the two layers appear to have been produced by a previous periclinal division in the outer (fig. 17).

The outer epidermis in the two prune varieties divides primarily by anticlinal walls. Since occasional periclinal divisions are not followed by radial cell enlargement, the epidermal layer maintains a uniform thickness. The incidence of pericinal divisions, which is more pronounced after flowering, is somewhat greater in the Imperial than in the French prune. Guard cells

are notable only by virtue of their greater tangential diameter and very deeply staining contents (figs. 17, 19, 20). In some cases, the surface of the ovary is slightly indented in the region of the future stoma. No cuticle is visible at this stage of development, nor are any trichomes to be found. In radial longisection, the epidermal cells are tabular as a result of numerous transverse divisions (fig. 18).

Development of the "Pit." During the period of bloom, the originally single-layered inner epidermis begins to divide actively by periclinal as well as anticlinal walls (figs. 5, 6, 7). Frequently oblique walls are encountered. Thus, at the end of the flowering period, this layer may comprise a tissue two or three cells wide. The cells expand little subsequent to division, with the result that they are quite small in transverse and longitudinal section. Only in a few ovaries toward the end of flowering is there the start of a slight vertical elongation of these cells, and then usually at the lateral and dorsal sides of the ovary wall (fig. 6). Periclinal divisions also may begin in the layer lying next to the inner epidermis, resulting in 2–3 cells in radial rows by the time the petals wither. Some cells in this second layer may begin to enlarge, particularly in the tangential plane.

Within a week and a half to two weeks, mitotic activity becomes intense in the three layers destined to form the pit (figs. 9, 10). Over most of its extent, the inner epidermis continues to divide. Its cells become smaller as the layer grows to 4–6 tangential rows. Only in the region of the ovular bundles is the inner epidermis relatively inactive, being maintained here as a single layer of cells. In this latter region also, the cells are still more or less tabular in longisection while they elongate in other parts of the young fruit.

The cells adjacent to the inner epidermis continue their course of periclinal divisions, marked also by conspicuous tangential elongation (fig. 10). These cells enlarge radially somewhat, but the radial enlargement is not as marked as the tangential. Due to continually occurring transverse divisions, the vertical diameter of the cells in this zone remains relatively small and their radial longisectional shape isodiametric (fig. 7). On the lateral faces and at the dorsal bundle, 4–6 layers of these cells are present. There are 10 layers of cells in this position at the ovular bundles, but here divisions are not so precisely periclinal; the cells divide in all planes to give isodiametric derivatives. At the stylar end of the ovary, occasional cells of this layer as well as of the next outer layer become crystalliferous. These idioblasts are filled with a large druse or a solitary crystal.

Cells in the outermost zone continue to divide in all planes, yielding a group of isodiametric cells which comprises 8–10 layers within two weeks after flowering. Isolated cells of this layer also contain crystals, particularly druses, at this time. In addition, the cells enlarge somewhat during the two

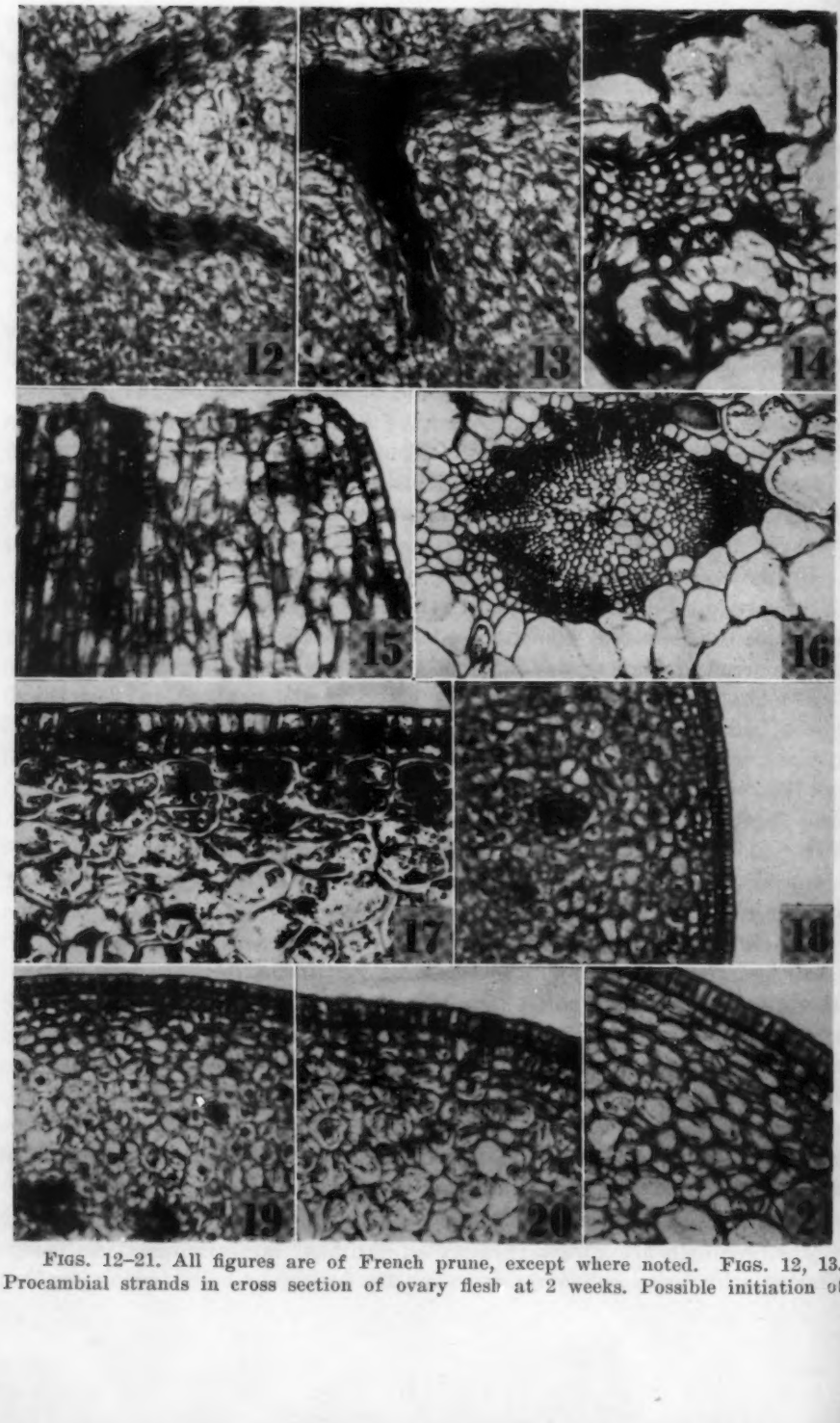
week interval. This layer of cells is most extensive in the regions of the ovular bundles and the dorsal bundle, forming a much thicker tissue in these regions than on the lateral faces.

The pattern of development outlined above continues for several weeks. By four weeks, wall-thickening and lignification begins at the stylar end of the pit area. Lignification proceeds very slowly in a basipetal direction during the following four weeks but does not reach the level of the top of the locule. In addition, crystal idioblasts appear more abundantly throughout these layers (fig. 11) (fewer, however, in the stratum derived from the inner epidermis). In *Potentilla*, *Fragaria*, and *Geum* Tschierske (1886) noted that crystals were restricted to a unicellular layer in the position equivalent to that of the outermost zone of *Prunus*. Mitotic figures are still numerous four weeks after flowering, but after six weeks (fig. 8), they can be found only in the two interior strata (the innermost layer of vertically elongating cells derived from the inner epidermis and the juxtaposed layer of tangentially elongating cells). Vertical elongation continues in the cells of the innermost layer, and tangential enlargement proceeds in the cells of the layer next to it.

By the eighth week after flowering, when division activity has ceased in all three strata, the innermost layer is 10 cells wide on the lateral faces and is composed of narrow elongate cells which extend vertically along the ovarian cavity. Somewhat wider cells, but elongated tangentially, lie in 12–14 (French) to 16–18 (Imperial) layers in the next group. The third layer of isodiametric cells is 14–18 (French) to 20–24 (Imperial) cells wide. At eight weeks, the definitive cell size in the pit area has been reached, and wall thickening and lignification (as indicated with phloroglucinol and HCl) occur throughout the entire area (fig. 11). The cell walls in all cases become thicker and are abundantly supplied with simple pits. Lignification begins first in the middle lamella and then proceeds in the cell walls proper. Further changes in the pit region were not followed.

Development of the "Flesh." Continuing divisions in all planes during a four week period produce the total number of flesh cells which will be present in the mature fruit. At a lateral face, this amounts to about 43 layers of cells in the French prune and about 48 layers in the Imperial prune. By the end of four weeks, this full complement of cells has been produced: no mitotic figures may be found at this time or subsequently. Cell enlargement proceeds continually from the time of flowering. Large, solitary druses appear early (within two weeks) in isolated cells here as well as in those of the pit. Tiny intercellular air spaces arise within two weeks after anthesis, but these never become very large.

The flesh cells are always thin-walled and have large vacuoles. An early differentiation among them occurs when the innermost cells (adjoining the



FIGS. 12–21. All figures are of French prune, except where noted. FIGS. 12, 13. Procambial strands in cross section of ovary flesh at 2 weeks. Possible initiation of

pit) start elongating radially. Despite subsequent enlargement in other planes, the interior cells always have a much larger radial than tangential diameter. On the other hand, the flesh cells near the outer surface of the fruit tend to elongate tangentially, particularly in the late stages of fruit growth (figs. 22–24). The cells lying between these two regions, enclosing the major part of the vascular network, enlarge uniformly to become large and isodiametric. The average cell diameter increase in the French prune is from 15 μ to 280 μ; in the Imperial, it is from 15 μ to 312 μ.

The druse-containing idioblasts rarely enlarge to the same degree as the surrounding cells. They occur principally in the neighborhood of the vascular bundles but may also be found far from these in the flesh, singly or in a strand of juxtaposed cells. Surrounding cells occasionally appear to be radiating from the idioblasts, perhaps due to restriction of wall growth in the faces in contact with the latter.

Except for the ovular bundles and the lower parts of its branches, which are embedded in the pit, all the vascular bundles may be considered as part of the flesh region. (The dorsal bundle and wing bundles lie in sulci at the surface of the pit). Branching and anastomosis occur during the first few weeks after flowering (figs. 12, 13). At the end of the fourth week, only a very few bundles in the state of undifferentiated procambium may still be found, usually adjacent to the pit. Vascular differentiation continues in all the bundles; and during enlargement of the flesh cells, cambia lay down secondary xylem and phloem in many. However, some bundle ends remain small and are composed only of trachery elements.

The orientation of the longitudinal bundles varies. In most, the xylem faces the pit, but in many it may face laterally or even to the outside, in a complete inversion. In horizontal bundles, also, there is no constancy in the orientation of xylem and phloem. Many bundles show stages of transition between collateral and concentric (amphicribral) structure. The latter condition appears to develop from the former by the extension of an interfascicular cambium through the parenchyma in the form of a cylinder, which

bundle branch at upper left of Fig. 12. × 171. FIG. 14. Cross section of vascular bundle of Imperial prune at 22 weeks. Note gummosis of phloem regions abaxial and adaxial to xylem. × 171. FIG. 15. Longisection of abscission region of style at 2 weeks. Periclinal divisions indicate organization of peridermal cicatrix. × 171. FIG. 16. Cross section of concentric bundle in flesh of Imperial prune at 18 weeks. × 89. FIG. 17. Cross section of outer region of ovary wall at flowering. Paired deeply stained cells in epidermis are guard cells. Periclinal divisions being initiated in outer and inner hypodermal layers. × 440. FIG. 18. Longisection of outer ovary wall of flower at initiation of periclinal divisions in outer hypodermal layer. × 171. FIG. 19. Cross section of outer ovary wall of flower with products of periclinal divisions in hypodermal layers somewhat enlarged. × 171. FIG. 20. Cross section of outer ovary wall at two weeks. Uniform periclinal division walls throughout both inner and outer hypodermal layers produce hypodermis of four cells which are elongating tangentially. × 171. FIG. 21. Cross section of outer ovary wall at 4 weeks. Outer hypodermal layer becoming three cells deep at places. × 171.

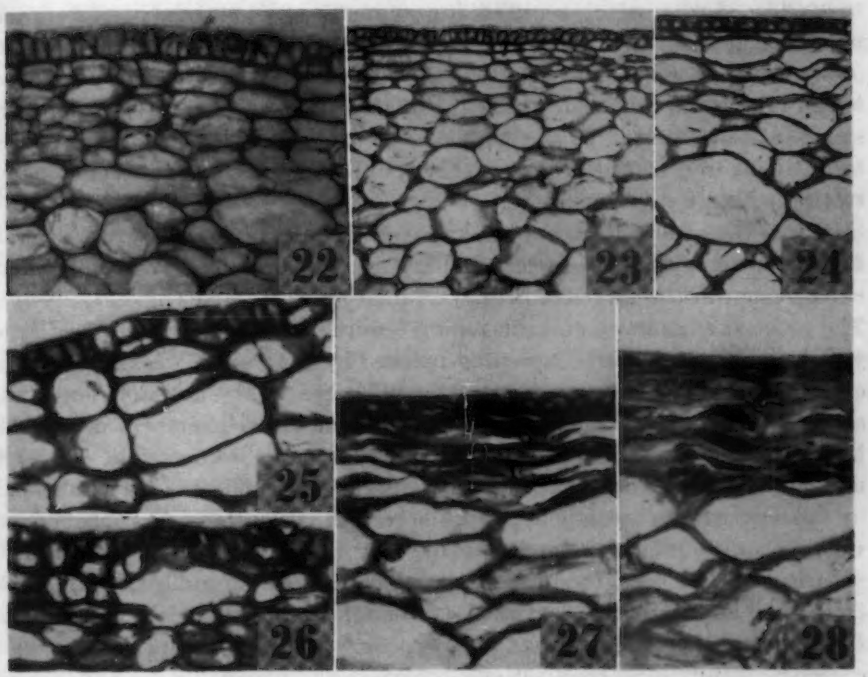
then lays down secondary vascular tissues (fig. 16). Bonne (1928) described amphicribral bundles in the floral tissues of many other Rosaceae.

Towards the time of fruit maturity, gummosis (*i.e.*, digestion of the tissues to produce a gummy residue) occurs in the phloic tissue of a large number of vascular bundles (fig. 14). This phenomenon involves more bundles and a greater percentage of the tissues in a bundle in the Imperial than in the French prune. Gummosis can occur in the former as early as the twelfth week after flowering, often involving tracheary elements in that variety. Gummosis in the wood of members of the genus is well-known and has also been described in the vascular bundles of the fruit of various species by Wigand (1863), Beijerinck (1914), Ragland (1934), and Miličić (1949). At the time of fruit fall (20 weeks after flowering in both varieties during the 1951 season), bundle gummosis is much more prevalent than earlier.

At maturity, the flesh parenchyma cells of both varieties begin to separate. In this process, the middle lamella loses its deeply-staining quality and swells, becoming granular-reticulate in the fixed material. Simultaneously its differential staining hue is lost, so that it stains the same color as the primary wall. The cell walls are moved farther apart, become undulate, and bulge into the cell lumina. Eventually, as in peach (Addoms, Nightingale and Blake 1930), the cell walls themselves begin to break down, leaving many large cavities in the flesh. This breakdown is accelerated following fruit abscission, involving an almost complete loss of stainability in the cell wall together with wall thinning and cellular collapse. The crystalline druses persist. Only in the neighborhood of the skin are the parenchymatous cells maintained more or less intact for any length of time after maturity. Cell separation very likely results from the same phenomenon noted in peach (Appleman and Conrad 1926) and in many other fruits and vegetables: a transformation of insoluble pectic materials of the primary wall and middle lamella into soluble pectin.

Development of the "Skin." As in other fruits, the skin of the prune is a composite structure, consisting in these varieties of the layer of outer epidermis with the cuticle and the derivatives of the two hypodermal layers immediately subjacent. During growth of the young fruit, anticlinal divisions in various planes in the epidermis produce cells which are polygonal in surface view. Single periclinal divisions also occur in the epidermis, abundantly in the Imperial and somewhat more sparingly in the French prune, forming two tiers of cells in this layer, (figs. 25, 26) as in almond (Garcin 1890) and peach (Curtis 1928, Miličić 1949). These periclinal divisions are often succeeded by anticlinal divisions in the daughter cells (figs. 23, 26). However, since there is little radial expansion of the cells produced by periclinal walls, the epidermis is clearly a discrete layer. Mitotic figures may be found here up to six weeks after flowering. By eight weeks, most divi-

sions have ceased, and the cells begin to expand radially and tangentially and develop thickened walls, particularly on their outer surface (fig. 22). Cell enlargement occurs about two weeks earlier in the French than in the Imperial prune. Occasional anticlinal division walls formed after wall thickening starts remain much thinner than the walls of the parent cells. Consequently, many epidermal cells appear to have a paired configuration in sections, a phenomenon noted by Curtis (1928) in plums and by Zschokke



FIGS. 22–28. All figures are cross sections. FIG. 22. Outer region of French prune at 6 weeks. Note cuticle. × 171. FIG. 23. Outer region of French prune at 8 weeks. Stoma at upper right. Incidence of periclinal divisions in epidermis. × 89. FIG. 24. Outer region of French prune at 18 weeks. Hypodermal layers embrace 5–6 cells as derivatives of original outer and inner layers. × 89. FIG. 25. Outer region of Imperial prune at 12 weeks. Periclinal divisions numerous in epidermis. × 171. FIG. 26. Outer region of Imperial prune at 12 weeks. Substomatal space is surmounted by guard cell in longisection. Note epidermal periclinal divisions. × 171. FIG. 27. Other region of French prune 2 weeks after abscission. × 171. FIG. 28. Outer region of Imperial prune 2 weeks after fruit abscission. Note swollen cell walls in hypodermal region. × 171.

(1897) in pomoidean fruits. Overlying the epidermal cells is a cuticle which first achieves noticeable thickness about four weeks after anthesis. In the French prune, the cuticle is thicker than in the Imperial at all stages of development. Its maximum thickness is reached at 12 weeks, at which time it is 4 μ thick in the French fruit and about 2.7 μ in the Imperial fruit. How-

ever, the cuticle becomes thinner in both varieties during fruit enlargement incidental to final maturation, as reported by Tukey and Young (1939) in sour cherry and apple (1942) and by Mitchell (1950) in pear. Only at the abscissed surface of the stylar base is the epidermis interrupted. Here, cicatrization is initiated by periclinal divisions in the cells below the wound surface, which early form a periderm (fig. 15).

Below the stomata, the hypodermal layers are interrupted by air chambers (figs. 23, 26), which begin to appear in the second week. Elsewhere the hypodermal cells divide by periclinal walls, occasionally anticlinal and oblique, until about six weeks after flowering. Some periclinal divisions have been found in the Imperial prune at this time, and a solitary anticlinal division has been found at 12 weeks. The outer hypodermal layer may give rise to from one to four cells in a radial row, and the inner layer to from one to two cells before divisions cease.

From the second week on, the hypodermal cells undergo a great deal of tangential elongation but little radial expansion (with more noticeable radial enlargement in the Imperial prune) as their walls thicken (figs. 17, 19–24). The greatest amount of wall thickening occurs in the first two strata of cells just below the epidermis, becoming marked by the eighth week. The thickened cell wall is highly birefringent in polarized light—more obviously so, and earlier, in the French prune. Where substomatal chambers occur, the hypodermal cells are shorter tangentially and more isodiametric. Towards maturity, the hypodermal cells in these regions become lignified (indicated by the phloroglucinol method), with the result that lenticel-like spots become visible on the surface of the fruit. However, neither phellogen activity nor suberization has been found in connection with this lignification, and the epidermis is not pushed outward. Although Valleau (1915) and Curtis (1928) found proliferation of the hypodermal cells within the stomatal chamber in plums, no such activity occurs in the prune. Tukey and Young (1939) report the absence of true lenticels in *P. cerasus* even at 60 days following commercial harvest of the fruit. Neither torn epidermal areas nor so-called "secondary epidermis" (Curtis 1928) occur in the prunes studied.

At fruit abscission, wall thickness and cell turgidity in the skin of both varieties appears normal. However, within two weeks after fruit drop, the cells of epidermis and hypodermis seem to collapse in the Imperial prune (fig. 28). Some radial compression occurs in the hypodermal cells of the French prune, but the epidermal cells retain their original shape (fig. 27). In addition, the disintegration characteristic of the flesh cells begins to appear in the hypodermal cells of the Imperial prune. That is, the cell walls become undulate, the middle lamella and the primary walls widen very greatly and show a light reticulate structure. These phenomena are not evident in the hypodermal layers of the French prune at this period.

Discussion. When Richard (1819) described the "pericarp" and its parts, he defined the "epicarp" of the fruit as the outer epidermis, the "endocarp" as its inner epidermis, and the intervening parenchymatous tissue as "sarcocarp." In drupaceous fruits, such as the peach, he viewed the pit ("putamen") as being composed of the endocarp united with an indurated portion of the sarcocarp. Richard's definitions have been followed by Cave (1869), Garcin (1890), and Tukey and Young (1939). Nevertheless, the whole stony region of the drupe has come to be called endocarp by other investigators, such as Sachs (1874), Bordzilowski (1888), Farmer (1889), Hayward (1938), Eames and MacDaniels (1947), etc., while the skin (including both epidermis and hypodermal layers) has been taken as epicarp.

In order to establish homologies among drupaceous fruits, the term "endocarp" has been applied to all sclerified interior zones of various fruits. However, the tissues which are sclerosed may be quite different in origin and composition. Garcin (1891), for example, considers the fruits of *Ribes* and *Vaccinium* to be drupes because of the sclerification only of cells of the inner epidermis. He notes that other fruits (*Tropaeolum*) may have no epidermal participation in the formation of the stone. Still others may have varying numbers and kinds of layers of cells, in combination with the inner epidermis, giving rise to the pit. All are considered to be drupaceous principally on the basis of a hard and continuous internal envelope in the pericarp. The same conception is expressed by Farmer (1889) regarding the structure of the fruits of *Hedera* and *Sambucus*. Similarly, Potonié (1880) has dealt with the "drupe" of pear, and Tukey and Young (1942) in apple, followed by Mitchell (1950) in pear, have considered the matured carpels as "drupelets."

Thus, the fruits of unrelated genera may be given the same structural classification regardless of histological and morphological differences. The corollary of this viewpoint negates natural relationships according to the degree of sclerification of the various tissues of the pericarp. However, in *Prunus* the amount of sclerification and the composition of the pit in the different species varies widely. In *P. domestica,* we have seen that the pit is composed of an extensive internal zone of vertically elongated sclereids, a middle zone of tangentially elongated sclereids, and an outer zone of isodiametric sclereids, the whole enclosing only the two ovular bundles. According to Lampe (1886), there is a single (*i.e.,* undivided) layer of inner epidermal cells in the pit of *P. institia,* while the inner epidermis distintegrates completely in *P. acida. P. cerasifera* (Copper 1909) has but two zones in the pit: an inner small-celled zone and an outer of tangentially-elongated cells. In *P. cerasus,* Eames and MacDaniels (1947) report an inner layer of tangentially elongated sclereids and an outer with vertically elongated sclereids; (but Bordzilowski, 1888, describes the outer of the two layers as being com-

posed of isodiametric cells; and Tukey and Young, 1939, indicate three layers in the pit of this species, noting that, as in *P. domestica*, they enclose only the two "funicular bundles"). Gérard (1887) finds only a single bundle (presumably a fusion product of two ovular bundles) in *P. avium*. In the pit of *P. persica*, 10–12 bundles are enclosed (Ragland 1934); and in the almond (*P. amygdalus*), there are sclerous masses embedded in an internal zone of parenchyma, followed by a layer of parenchyma which encloses numerous vascular bundles, next a ring of sclerous cells, and on the outside tangentially elongated fibers (Cave 1869, Garcin 1891). Brooks (1940) also notes the presence of most of the vascular bundles of the almond fruit in the pit or in the "transition" tissue between pit and flesh. Finally, instances have been reported of the virtual lack of sclerified cells in the pit regions of fruits of some grafts of plum and of sour cherry (Marchant 1738).

Since the pit regions of the various closely-related species of *Prunus* are equivalent neither in tissue structure nor in vascular composition, the morphological significance of a pit in this genus is questionable. In other genera, homologies of the pit region perhaps may be suspect also. Accordingly, in the absence of compelling evidence, it seems unwise to group all these internal sclerified areas under the classification, "endocarp," and the writer suggests a return to Richard's original definition of this term. As a consequence of this viewpoint, structural differences between the pits of different species of a genus may be regarded as principally of taxonomic importance. Sclerosis of parenchymatous tissues by itself appears to constitute a weak foundation for a broad morphological system of fruit classification.

Although the term "epicarp" or "exocarp" is applied indiscriminately to the combined cuticular, peridermal, epidermal, and collenchymatous outer layers of a fruit (as well as including occasionally some outer layers of the flesh), its use has gained some condonation in the identification of these superficial tissues as the "skin." Since the morphological situation here may be similar to that with "endocarp," the writer proposes, for the sake of clarity, that the original definitions of Richard (1819) be followed. In *Prunus*, the collenchymatous layers are part of the outermost mesocarp, and gradual transitions between collenchymatous and parenchymatous characteristics are to be found in the underlying layers (*cf.* Curtis 1928, Garcin 1890, Lampe 1886).

Since many reviews in recent years have been concerned with the problem of the morphological nature of the carpel, it is unnecessary here to reexamine the literature on that topic. Suffice it to remark that a considerable number of present-day botanists believe that carpels resembling those of primitive Angiosperms may be found among such orders as the Magnoliales, Ranales, or Rosales. Essentially, this primitive carpel is taken to be a foliar, multi-ovulate structure of the follicle type (Juel 1918, Smith 1928, Chute

1930, Eames 1931, Fraser 1937, Juhnke and Winkler 1938, Wilson and Just 1939, Bailey and Nast 1943). Thus, among the living genera of the Rosaeae, carpels resembling those of the primitive parent stock are presumably to be found among the Spiraeoideae, particularly in such genera as *Physocarpus, Spiraea, Gillenia, Quillaja,* and *Kageneckia,* which usually have five free multiovulate carpels on the receptacle. Reduction in the number of ovules per carpel is believed to have led to the production of the more

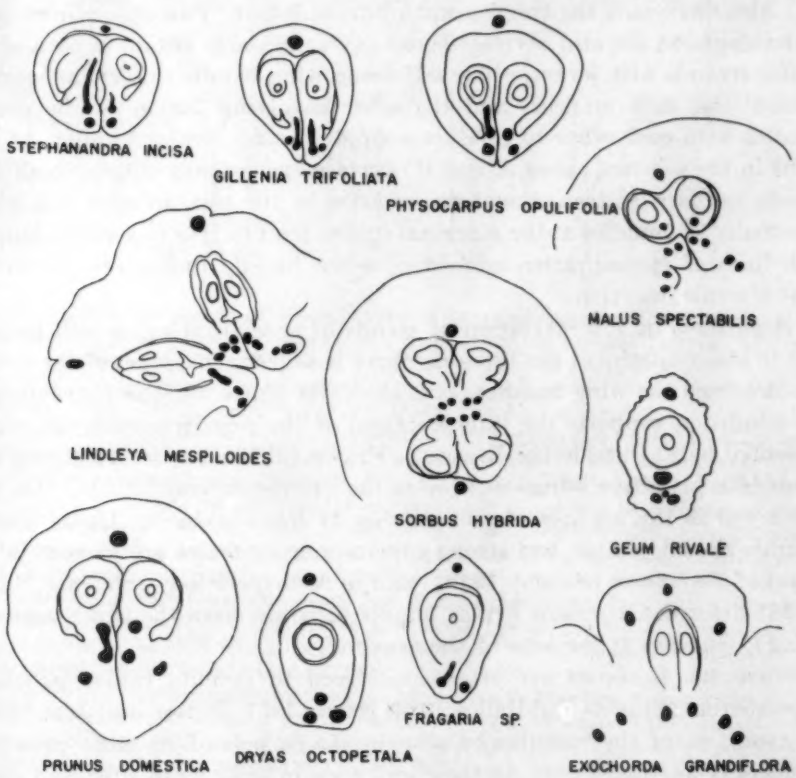


FIG. 29. Cross sections of the ovaries of some rosacean species, all but *Fragaria* showing wing bundles as a constant feature of vascularization. Compare with diagrammatic representation of same species in figure 30. *Stephanandra, Gillenia, Geum, Dryas,* and *Fragaria* after Juel (1918); *Physocarpus, Malus, Lindleya, Sorbus,* and *Exochorda* after Bonne (1928); *Prunus,* original.

simplified drupes and achenes characteristic of the other members of the family, as the Prunoideae and Rosoideae (Chute 1930, Eames 1931).

If the vascularization of the carpel is traced from the Spiraeoideae to the Rosoideae, there also occurs a progressive reduction and fusion in the vascular traces (fig. 30). The latter figure presents a speculative interpre-

tation of such trends of vascular specialization, based principally on the descriptions of Tschierske (1886), Juel (1918), Saunders (1927), Bonne (1928), and Chute (1930). The hypothetical primitive rosacean carpel is given at 1.[3] At the suture, this carpel is characterized by two complex ovular bundles, supplying two rows of marginal ovules, and two wing bundles, one on either side of the ovular group. From the primitive condition to the advanced, a general tendency toward the reduction of ovule number is apparent. Also obvious is the trend toward bundle fusion. Two subordinate lines of development are also envisaged: one involving early fusion of each of the ovular strands with its respective adjoining wing bundle to form a "ventral bundle" on each margin; and the other involving fusion of the ovular bundles with each other to produce a single median ovular bundle. At any point in the scheme, (as at A and B) certain species may display both subtrends, perhaps as transitional stages between the two. In each sub-trend, eventually all bundles at the marginal suture tend to fuse to a single bundle, both lines of specialization coinciding when bundle fusion reaches to the level of ovule insertion.

Regardless of interpretation of trends of specialization, it will be seen that in many species of the Rosaceae there is a clear separation of the ovular bundles from the wing bundles, as is shown in figure 29. The prevalence of this condition supports the interpretation of the primitive rosacean carpel presented here. Outside the Rosaceae, Fraser (1937) has found strong evidence of a primitive 5-trace supply to the ranunculacean follicle (this was also noted in the achenes of some species of *Ranunculus* by Chute 1930); separate dorsal, ovular, and strong supernumerary traces are present in the carpel of *Degeneria* (Swamy 1949); and in *Menispermum canadense*, Smith (1928) described a unique ovular bundle separate from the two "ventral" (wing?) bundles at the base of the ovary.

Since the Rosaceae are often considered to include rather primitive Angiosperms (Sinnott and Bailey 1914, Eames 1931, Wilson and Just 1939), the condition of the vascular bundles in the carpels of its more primitive members is worthy of note. In these and even in some more advanced members of the family, the vascular supply of the ovules is independent of the three other main carpel bundles. Inasmuch as vascular anatomy is taken to supply the "strongest" evidence in the interpretation of flower structure (Eames 1929), the data on vascularization presented here must be consid-

[3] All the other diagrams are reconstructed from figures or textual descriptions of vascularization in living plants. It is necessary to stress that some of the constructions have been based on analysis of cross-sectional figures, on text descriptions, and on complementary details from several authors, where possible. In some cases, in which a different description of the same species has been provided by each of two authors, both schemes are indicated in the figure description. Since the bundles are presented from their dorsal aspect, the dorsal bundle of the carpel is not shown.

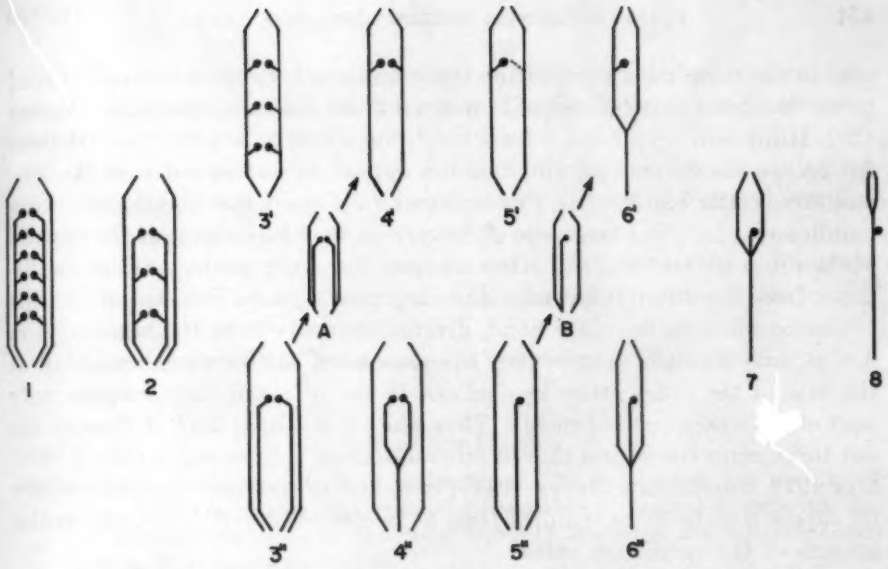


FIG. 30. Possible trends of specialization in vascularization of the rosacean carpel. Diagrammatic representations of vascular construction of sutural margins as viewed from the dorsal edge of the carpel. 1. Hypothetical primitive carpel, with two separate wing bundles on either side of compound ovular strands. 2. Carpel of the type of *Gillenia trifoliata* (Juel, 1918), *Physocarpus opulifolia* (Bonne, 1928) and possibly *Cydonia japonica* (Juel 1918, Bonne, 1928). The condition in 2. gives rise to that in 3′ by fusion of ovular and wing bundles, to that in 3″ by reduction in number of ovules. 3′ Fusion of ovular bundles with wing bundles, as occurs partially (perhaps as a transition between 2 and 3′) in *Spiraea ulmifolia* (Juel, 1918) and completely in *Sorbaria sorbifolia, Gillenia stipulacea* (Bonne, 1928), *Spiraea spp.* and *Stephanandra spp.* (Saunders, 1927). 3″. Reduction in number of ovules without fusion of wing and ovular bundles, as is characteristic of most species of *Prunus* and of *Nuttallia cerasiformis* (Saunders 1927), presumably *Stephanandra incisa* and *Pyrus arbutifolia* (Juel, 1918), *Exochorda grandiflora, Sorbus hybrida,* and *Malus spectabilis* (Bonne 1928). *A.* Basal fusion of wing and ovular bundles which occurs in *Exochorda Alberti* (Saunders 1927), *Prunus padus* (Bordzilowski 1888, Saunders 1927), and *Lindleya mespiloides* (Bonne 1928). 4′. Two ventral bundles, each producing an ovular trace. This condition may be derived either from that in 3′ or in *A* and is found in *Prunus cerasus* (Van Tieghem 1868), *Vauquelinia corymbosa* and *Fallugia paradoxa* (Juel 1918), *Pyrus malus, Photinia integrifolia,* and *Sorbus torminalis* (Bonne 1928), and *Stephanandra flexuosa* (Bonne 1928, Sanuders 1927). 4″. Basal fusion of two ovular bundles while wing bundles remain separate: *Rubus Idaeus* (Tschierske 1886), *Prunus avium* (Gérard 1887), and often *P. persica* (Ragland 1934). 5′ and 5″ reduction of ovules from two to one. 5′. As shown, in *Waldsteinia fragarioides* (Chute 1930); *sans* extra trace in *Geum rivale* (Juel 1918), and *Waldsteinia geoides* (Juel 1918, Saunders 1927); 5″. In *Cowania mexicana* and *Kerria japonica* (Juel 1918) and *Purshia tridentata* (Juel 1918, Saunders 1927). *B.* Fusion of ovular bundle (to single ovule) with one ventral bundle-*Kerria japonica,* (Saunders 1927). 6′. Basal fusion of two ventral strands, described in *Poterium canadense* (Saunders 1927) and *Fragaria vesca, Agrimonia striata,* and *Potentilla recta* (Chute 1930). Two ovules are present in *Rubus hispidus* and *Dalibarda repens* (Chute 1930). 6″. Basal fusion of two wing bundles with ovular bundle; as in *Dryas octopetala* (Juel 1918), *Chamaebatia foliolosa* (Juel 1918, Bonne 1928), *Cercocarpus parvifolius,* (Juel 1918, Saunders 1927) *Geum rivale* and *Duchesnea indica* (Chute 1930). 7. Fusion of all bundles to level of ovule insertion, with branches as single ovular trace and two upper bundles to style, as in *Potentilla anserina* (Tschierske, 1886) and *Cercocarpus betulaefolius* (Saunders 1927). This condition may be derived from 6′ or 6″. 8. Bundle fusion occurs above the level of ovular trace insertion. *Alchemilla fissa* (Saunders 1927) and perhaps *Poterium sanguisorba* and *Acaena pinnatifida* (Bonne 1928).

ered in assessing the nature of the rosacean carpel. Little evidence is found in the Rosaceae that the carpel is derived from a 3-trace structure (Eames 1931, Hunt 1937); rather a 5-trace condition seems to be primitive. Of these five traces, the dorsal and wing bundles appear to correspond with the normal three foliar bundles.[4] In *Prunus domestica*, the dorsal and the two wing bundles are of similar large size at flowering; they lie in sulci at the surface of the pit in the mature fruit; they traverse the ovary at about the same distance from the outer epidermis; and they pass upward into the style. The ovular bundles, on the other hand, diverge inwardly from the bundle cylinder in their upward course; they are associated with a vascular island at the base of the ovary; they lie enclosed in the pit; and they traverse only part of the ovary to the funiculi. Thus, since the foliage leaf of *Prunus* has but three main traces and that of other Rosaceae is typically 3-traced (Sinnott 1914, Sinnott and Bailey 1914), it would appear that morphologically its carpel may be more complex than a "megasporophyll"; *i.e.*, the ovular strands of the carpel are extra.

Whether the ovular strands are tokens of an ancestral ovule-bearing branch system which has fused with a subtending leaf (as Payer 1857, suggested for the angiosperm carpel and Florin 1938–1945, demonstrated in the coniferous cone scale) or whether their presence has a different morphological significance cannot be ascertained on the basis of the present study. Detailed ontogenetic and comparative studies of carpels of the more primitive Rosales should provide a clue to the solution of this interesting problem.

SUMMARY

1. The ovary of the prune is uniloculate, enclosing two anatropous ovules. One of the ovules disintegrates during fruit development.

2. In the formation of the drupaceous fruit, three internal histogen-like layers of the ovary give rise to three distinct tissues of the pit: the inner epidermis forms a multiseriate layer of vertically elongated sclereids; the next outer stratum of cells forms a multiseriate layer of tangentially elongated sclereids; and the following 2–4 layers produce a zone of isodiametric sclereids.

3. The skin of the fruit is composed of the cuticle, epidermis (which may be periclinally divided at various places), and 2–6 layers of collenchymatous cells derived from two hypodermal layers in the ovary. No lenticels are formed.

4. The flesh includes most of the vascular bundles of the fruit, which are embedded in parenchymatous tissue.

[4] In foliated, ovule-less carpels and other foliar organs of *Prunus paniculata*, Rauh (1951) has shown that the two lateral veins (equivalent to the wing bundles) are removed somewhat from the margins, as are the wing bundles described here.

5. Two ovular bundles are embedded in the lignified tissues of the pit. Lying in sulci at the surface of the pit are the dorsal bundle and two wing bundles.

6. Evidence is presented that the dorsal and wing bundles are equivalent to the three bundles of the other foliar organs of *Prunus* and that the ovular bundles are separate structures.

7. The suggestion that the rosacean carpel is primitively a five-trace organ is supported by a comparative review of the structure of the carpel in other members of the Rosaceae.

Department of Food Technology, University of California
Davis, California

Literature Cited

Addoms, R. M., Nightingale, G. T., & Blake, M. A. 1930. Development and ripening of peaches as correlated with physical characteristics, chemical composition, and histological structure of the fruit flesh: II Histology and microchemistry. Bull. N. J. Agr. Exp. Sta. 507.

Appleman, C. O. & Conrad, C. M. 1926. Pectic constituents of peaches and their relation to softening of the fruit. Bull. Maryland Agr. Exp. Sta. 283.

Bailey, I. W. & Nast, C. G. 1943. The comparative morphology of the Winteraceae. II. Carpels. Jour. Arnold Arb. **24**: 472–481.

Beijerinck, M. W. 1914. Gummosis in de Amandel-en Perzikamandelvrucht als normaal ontwikkelingsverschijnsel. Versl. Gewone Vergad. Akad. Amst. **23**: 531–542.

Bonne, G. 1928. Recherches sur le pédicelle et la fleur des Rosacées. Paris.

Bordzilowski, J. 1888. De la manière du développement des fruits charnus et baies. Mém. Soc. Nat. Kieff. **9**: 65–106.

Brooks, R. M. 1940. Comparative histogenesis of vegetative and floral apices in *Amygdalus communis*, with special reference to the carpel. Hilgardia **13**: 249–299.

Cave, C. 1869. Structure et développement du fruit. Ann. Sci. Nat. Bot. V. **10**: 123–190.

Chute, H. M. 1930. The morphology and anatomy of the achene. Am. Jour. Bot. **17**: 703–723.

Conant, G. H. 1950. Triarch quadruple stain. Triarch Catalog No. 8 (Ripon, Wis.): 20, 30.

Copper, A. C. 1909. Beiträge zur Entwicklungsgeschichte der Samen und Früchte offizineller Pflanzen. Inaug.-Dissert. Univ. Bern. Utrecht.

Croizat, L. 1947. A study in the Celastraceae. Lilloa **13**: 31–43.

Curtis, K. M. 1928. The morphological aspect of resistance to brown rot in stone fruit. Ann. Bot. **42**: 39–68.

Dorsey, M. J. & Potter, J. S. 1932. A study of the structure of the skin and pubescence of the peach in relation to brushing. Bull. Illinois Agr. Exp. Sta. 385.

Eames, A. J. 1929. The rôle of flower anatomy in the determination of angiosperm phylogeny. Proc. Int. Congr. Pl. Sci. (Ithaca, 1926) **1**: 423–427.

———. 1931. The vascular anatomy of the flower with refutation of the theory of carpel polymorphism. Am. Jour. Bot. **18**: 147–188.

Eames, A. J. & MacDaniels, L. H. 1947. An introduction to plant anatomy. 2nd Ed. New York.

Farmer, J. B. 1889. Contributions to the morphology and physiology of pulpy fruits. Ann. Bot. **3**: 393–414

Florin, R. 1938–1945. Die Koniferen des Oberkarbons und des unteren Perms. Palaeontographica 85B (Hefte 1–8).

Fraser, M. S. 1937. A study of the vascular supply to the carpels in the follicle-bearing Ranunculaceae. Trans. Roy. Soc. Edinburgh. **59**: 1–56.

Garcin, A. G. 1890. Recherches sur l'histogénèse des péricarpes charnus. Ann. Sci. Nat. Bot. VII. **12**: 175–401.

———. 1891. Du noyau des drupes, histologie et histogénèse. Contribution a l'étude des péricarpes charnus. Ann. Soc. Bot. Lyon **17**: 27–39.

Gérard, R. 1887. Traité pratique de micrographie. Paris.

Harrold, T. J. 1935. Comparative study of the developing and aborting fruits of *Prunus persica*. Bot. Gaz. **96**: 505–520.

Hayward, H. E. 1938. The structure of economic plants. New York.

Hunt, K. W. 1937. A study of the style and stigma, with reference to the nature of the carpel. Am. Jour. Bot. **24**: 288–295.

Juel, H. O. 1918. Beiträge zur Blütenanatomie und zur Systematik der Rosaceen. K. svenska Vetenskakad. Handl. **58**: No. 5.

Juhnke, G. & Winkler, H. 1938. Der Balg als Grundelement des Angiospermengynaeceums. Beitr. z. Biol. d. Pflanzen **25**: 290–324.

Lampe, P. 1886. Zur Kenntniss des Baues und der Entwickelung saftiger Früchte. Zeitschr. f. Naturwiss. **59**: 295–323.

Marchant, M. 1738. Observation sur un nouveau phénomene concernant la structure du fruit d'une espece de Prunier. Hist. Mém. Acad. Sci. Paris (1735): 373–378.

Miličić, D. 1949. The anatomical structure of the epicarp of the peach and some particularities in the mesocarp. Izv. Bot. Inst. Univ. Zagreb **12/13**: 207–230.

Mitchell, A. E. 1950. Gross morphology and histology of the developing fruit of the Bartlett pear. Ph.D. Thesis. Ohio State Univ.

Payer, J. B. 1857. Traité d'organogénie comparée de la fleur. Paris.

Potonié H. 1880. Über die Bedeutung der Steinkörper im Fruchtfleische der Birnen und der Pomazeen u. überhaupt. Kosmos **8**: 33–36.

Ragland, C. H. 1934. The development of the peach fruit, with special reference to split-pit and gumming. Proc. Amer. Soc. Hort. Sci. **31**: 1–21.

Rauh, W. 1951. Morphologische und histogenetische Beobachtungen an verlaubten Fruchtblättern von *Prunus paniculata* Thb. Beitr. z. Biol. d. Pflanzen **28**: 160–172.

Richard, L. C. 1819. Observations on the structure of fruits and seeds. London.

Sachs, J. 1874. Lehrbuch der Botanik. 4te Aufl. Leipzig.

Sass, J. E. 1940. Elements of botanical microtechnique. N. Y.

Saunders, E. R. 1927. On carpel polymorphism. II. Ann. Bot. **41**: 569–627.

Sinnott, E. W. 1914. Investigations on the phylogeny of the angiosperms. 1. The anatomy of the node as an aid in the classification of angiosperms. Am. Jour. Bot. **1**: 303–322.

Sinnott, E. W. & Bailey, I. W. 1914. Investigations on the phylogeny of the angiosperms. 3. Nodal anatomy and the morphology of stipules. Am. Jour. Bot. **1**: 441–453.

Smith, G. H. 1928. Vascular anatomy of ranalian flowers. II. Ranunculaceae (continued), Menispermaceae, Calycanthaceae, Annonaceae. Bot. Gaz. **85**: 152–177.

Swamy, B. G. L. 1949. Further contributions to the morphology of the Degeneriaceae. Jour. Arnold Arb. **30**: 10–38.

Tieghem, P. van. 1868. Recherches sur la structure du pistil. Ann. Sci. Nat. Bot. V. **9**: 127–226.

Tschierske, P. 1886. Beiträge zur vergleichenden Anatomie und Entwicklungsgeschichte einiger Dryadeenfrüchte. Zeitschr. f. Naturwiss. **59**: 580–628.

Tukey, H. B. & Young, J. O. 1939. Histological study of the developing fruit of the sour cherry. Bot. Gaz. **100**: 723–749.

————. 1942. Gross morphology and histology of developing fruit of the apple. Bot. Gaz. **104**: 3–25.

Valleau, W. D. 1915. Varietal resistance of plums to brown rot. Jour. Agr. Res. **5**: 365–396.

Wigand, A. 1863. Ueber die Deorganisation der Pflanzenzelle, insbesondere über die physiologische Bedeutung von Gummi und Harz. Jahrb. wiss. Bot. **3**: 115–182.

Wilson, C. L. & Just, T. 1939. The morphology of the flower. Bot. Rev. **5**: 97–131.

Zschokke, A. 1897. Ueber den Bau der Haut und die Ursachen der verschiedenen Haltbarkeit unserer Kernobstfrüchte. Landwirtsch. Jahrb. Schweiz. **11**: 153–197.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, No. 6, pp. 478–497 NOVEMBER, 1953

THE RACEMOSE VAUCHERIAE WITH INCLINED OR PENDENT OOGONIA*

JOHN L. BLUM

The Vaucheriae of the Section Corniculatae, Subsection Racemosae, may be divided arbitrarily into (1) those species possessing oogonia which are clearly upright (*Vaucheria geminata* (Vauch.) DC. and related forms) and (2) those which have tipped or inclined oogonia, attached to their pedicels in such a way that their long axes are more or less horizontal, or attached at the end of pendent branches of the fruiting stalk. The distinction between groups (1) and (2) is not clear cut; a few species do not fall definitely into either group, and a decision as to whether or not the oogonia are erect may be difficult to make, due to the fact that the elongated fruiting branches of these species are seldom observed turned in such a way (laterally) as to permit perfect observation of the tipping. This paper treats the species of the second group, as well as those species which might be assigned as readily to one group as to the other.

The species thus circumscribed for study are probably not all closely related. They appear to be separable into four subsidiary groups, two of which center around *V. terrestris sensu* Götz and *V. hamata sensu* Götz, with two remaining species, *V. uncinata* Kütz and *V. longata* sp. nov., apparently isolated in position. At least *V. hamata*, with its related species, has affinities with the *geminata* complex; another species (*V. uncinata*) has in the past been included in a separate genus (*Vaucheriopsis*) and may deserve to be set apart at least from the other species here considered on the basis of its oogonium, which is globose to subglobose in contrast to that of all the species ordinarily assigned to the Corniculatae. Of the known collections of the species considered in the present paper, none is from a definitely brackish or marine habitat.

The species have been assembled in this somewhat artificial manner because of certain superficial resemblances between them, and because of the difficulty of separating them adequately. Much of the taxonomic difficulty of *Vaucheria* lies within the present group of species. Due to a well developed tendency, which these species share with the *geminata* group, of producing abnormal and intermediate forms, the phycologist who wishes to make determinations must learn the range of appearance in each form and must observe a series of fructifications on each specimen. It is seldom possible to determine a species from the observation of a single fruiting branch.

* Illustrations published with the assistance of the Lucien M. Underwood Memorial Fund.

The accompanying figures show much of the range in the appearance of fruiting branches of the commoner species.

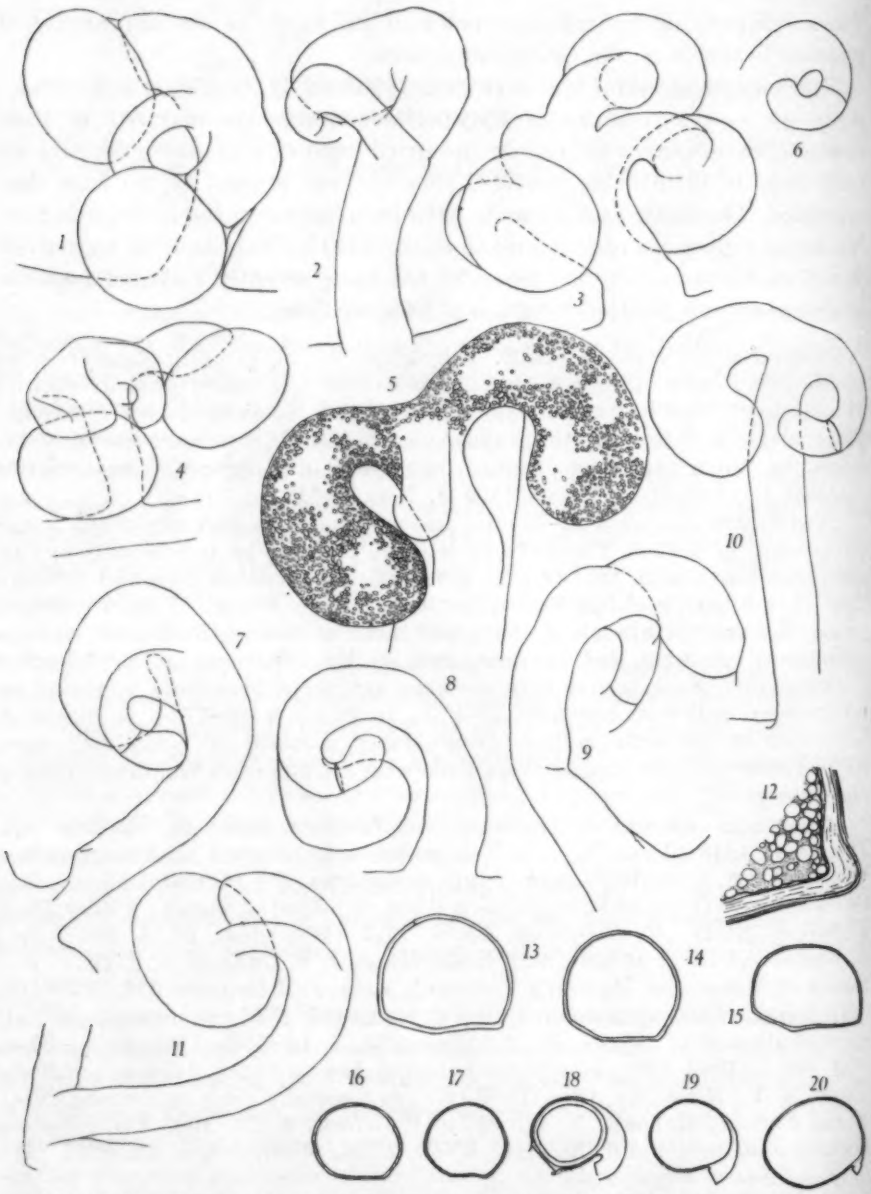
Herbarium material has been used extensively in the present study, inasmuch as the fresh water Vaucheriae preserve the majority of their characteristics nearly as well in the dried condition as in liquid, and remain readily identifiable provided they are not pressed at the time they are dried. The latter fact seems to have been known to the early collectors, for many collections of value made in the 1840's, '50's, and '60's are to be found in herbaria, whereas much of the more recently collected material was pressed and for that reason is nearly worthless.

VAUCHERIA UNCINATA Kütz., Tab. Phyc. 6: 21 (1856); *V. arrhyncha* Heidinger, Ber. deutsch. bot. Ges. 26: 362 (1908); *Vaucheriopsis arrhyncha* (Heidinger) Heering, Siphonales, A. Pascher, Süsswasserflora Deutschl., Österreichs, u. Schw., 7, Chlorophyc. 4: 96 (1921); —Here probably belongs, to judge from the original description and figures, *Vaucheriopsis sinensis* Ley, Sinensia 15: 95 (1944). Figs. 1–11.

Vegetative filaments 42–76 μ in diameter; oogonia and antheridia borne on a fruiting branch 170–500 μ in length; fruiting branch usually trifurcate, sometimes with two or four divisions, its divisions recurved through 180°, pendulous, and bearing respectively, on one branch if there are two, or on the central branch if there are three, a short cylindric or saccate, sometimes circinate, antheridium, and on the other branch or branches (always the two external ones if there are three branches) spherical or compressed spherical oogonia 120–150 μ in length $\times$ 135–175 μ in diameter. The wall of the antheridium disintegrates partially or completely soon after dehiscence. The oogonial wall likewise disintegrates rapidly, releasing the oospore.

Specimens examined: Germany: in frischen Brüchen, Freiburg, *A. Braun*, 9. 1846 (Type, R[1]); in Torfgruben schwimmend in Abzugsgräben, Grossauheim, 9. 14. 1846 (one of type collections of *V. hamulata* Kütz., R); Schleusingen (type of *V. sacculifera* Kütz., R). United States: Wilder Dam, Lebanon, N. H., *H. Croasdale*, 10. 8. 1937 (B); *idem*, 10. 3. 1940 (B); Coonamesset River at Sandwich Road, Mass., *J. T. Conover*, 8. 2. 1951 (B); South of Menemsha, Martha's Vineyard, Mass., *J. T. Conover*, 8. 2. 1951 (B); Mill River, Mass., *I. Holden*, 1892 (P. B.-A. 475, NY); in a creek one half mile southwest of Akron, N. Y., *Blum* 331, 7. 14. 1949 (B); *idem*, *Blum* 394, 10. 5. 1949 (B); in springs entering Lewey Lake, Adirondack State Park, N. Y., *Blum* 564, 10. 4. 1950 (B); in a marshy ditch in orchard, N. C. State College, Raleigh, N. C., *L. A. Whitford*, 4. 29. 1935 (B); Spring Swamp, Boone's Pond, Raleigh, N. C., *L. A. Whitford*, 5. 12. 1937 (B).

[1] Herbaria and other collections in which the specimens cited are filed are indicated by the following abbreviations: B, Collection of J. Blum; C, Cryptogamic Herbarium of the Chicago Natural History Museum; M, Herbarium of the University of Michigan; NY, Herbarium of the New York Botanical Garden; P, Collection of G. W. Prescott; R, Rijksherbarium, Leiden; S, Collection of Stanford University; SI, Herbarium of the Smithsonian Institution; T, Herbarium of Wm. Randolph Taylor.



FIGS. 1–20. FIGS. 1–11. *Vaucheria uncinata* Kütz. FIGS. 1–4. Type, from Freiburg. FIG. 5. From Grossauheim (cotype of *V. hamulata* Kütz.). FIG. 6. Antheridial stalk and antheridium just before dehiscence. From Lebanon, N. H. FIGS. 7, 8, 10, 11. From Coonamesset River, Mass., showing mature and immature oogonia. FIG. 9. From Lebanon, N. H., showing fruiting branch after detachment of oospore. FIG. 12. Receptive portion of oogonium and adjacent portions of oospore wall of *V. terrestris* as they ap-

This species was incompletely described but comparatively well illustrated in 1856. The type material from Freiburg is in a state of excellent preservation and there is no doubt as to the species to which Kützing's description referred. No antheridia are shown in his drawings, but this is understandable in light of the fact that antheridia in this species disintegrate quickly after dehiscence, and, in all except relatively immature material, are unusually difficult to locate and to see clearly.

The concept of this species underwent progressive modification as one publication succeeded another. Rabenhorst's description of 1863, while incomplete, is at least correct. His description of 1868 and those of Hansgirg (1888) and De Toni (1889) could apply as well to *V. walzi* Rothert. With the work of Götz (1897), Teodoresco (1907), Heering (1921), Hoppaugh (1930), and Dangeard (1939) the name *V. uncinata* Kütz. is clearly used in a different sense. As the drawings in Tabulae Phycologicae do not admit of misinterpretation, it is strange that Götz should have applied this name to material of an entirely different sort, and stranger still that subsequent workers in treating these species should all have adopted Götz's interpretation. Thus Heidinger (1908) interpreted another Freiburg collection of *V. uncinata* Kütz. as the type of a new species (*V. arrhyncha* Heidinger), and later workers have generally accepted Heidinger's name as well as a genus (*Vaucheriopsis*) which Heering (1921) constructed to accommodate it. There does not seem to be any room for doubt, however, as to the synonymy of these two entities (*Vaucheria uncinata* Kütz. = *V. arrhyncha* Heidinger). Heidinger's description would be exact for the type material of *V. uncinata;* his drawings are clearly referable to the same species. Of all fresh water *Vaucheria* species which possess a special fruiting stalk, none has oospores which approach the size of those of *V. uncinata* (120–150 × 135–175 μ); Heidinger states for his species, *V. arrhyncha*, "Oospora . . . diam. 150 μ."

Certain circumstances which might be interpreted to support the retention of *V. arrhyncha* Heidinger may be summarized as follows:

1. Kützing's description of *V. uncinata,* like those of most of the earlier and commoner species of *Vaucheria,* mentions unimportant characters and omits mention of some of the most important characters of the species.
2. Kützing gives no measurements as such. From his illustrations on

pear after treatment with 10% KOH solution; note the perforated oogonial wall and the much thickened median wall of the oospore. FIGS. 13–19. Diagrams of oogonia with oospores, of species considered in this study, in lateral view, to show the slight but characteristic differences in shape (the oospore of *V. uncinata* is shown in full lateral view in figure 1). FIG. 13. *V. terrestris* or *V. brevicaulis.* FIG. 14. *V. undulata.* FIG. 15. *V. longata* sp. nov. FIGS. 16, 17. *V. hamata* or *V. walzi.* FIG. 18. *V. aduncа,* after Jao. FIG. 19. *V. pseudo-geminata,* after Dangeard. FIG. 20. *V. alaskana* sp. nov. Figures 1—11 × 120, figure 12 × 550, other figures × 150.

Plate 60 (1856), magnified one hundred times, it is possible to determine that the oogonia drawn should measure about 85–100 × 90–120 μ, substantially below the size range for *V. arrhyncha*. However, from a study of the type material, it seems unlikely that precision is intended in the stated magnification; it is more significant that the oospores shown for this species are clearly larger than for any other racemose *Vaucheria* in the Tabulae.

3. The type sheet of a Kützing species (*V. hamulata*), regarded as invalid by the present author, bears three collections one of which is referable to *V. uncinata* Kütz. and clearly does not agree with Kützing's illustrations of *V. hamulata*. The other two "type" collections of *V. hamulata* are referable to *V. terrestris* as interpreted by Götz (1897).

4. The type material of another invalid Kützing species (*V. sacculifera*) is likewise referable to *V. uncinata* and clearly does not correspond to Kützing's illustrations of *V. sacculifera*.

In spite of these objections the case against the name *Vaucheria arrhyncha* seems ample to warrant its abandonment.

The antheridia of *V. uncinata*, although proportionately somewhat shorter than in most of the circinate species, are not essentially different from those of the other species; *V. uncinata* therefore should be placed in the Section Corniculatae, Subsection Racemosae, although, in view of its globose oogonia, in a position somewhat remote from all other known species.

The restoration of the name *Vaucheria uncinata* to the plant which Kützing undoubtedly intended to bear it raises a question as to the proper name applicable to the alga which has been called *V. uncinata* by later phycologists. This question necessitated a careful study of the entity itself and an accurate appraisal of the extent of its variability. Unfortunately, in spite of the relatively numerous collections of this entity which have been made, this puzzle is not satisfactorily solved. The "*V. uncinata*" which is illustrated clearly and well by Hoppaugh (1930) is a form with short fruiting branches and paired oogonia which has been found several times in New York by the author and which has been seen in many dried collections. Usually, but not always, in such material the fruiting branches with two oogonia are accompanied by scattered branches bearing three oogonia, arranged as in figures 22 and 23, but in some collections the forms bearing three oogonia are predominant over the others. In all collections, the formation of a second fruiting branch from the distal end of the first, as in other Vaucheriae of this group, seems to be a common phenomenon. The presence of four or five oogonia on one fruiting branch is of rarer occurrence, and has been observed consistently in only two unique European collections, those of Agardh (Lund) and Frémy (Sainteny). At least the

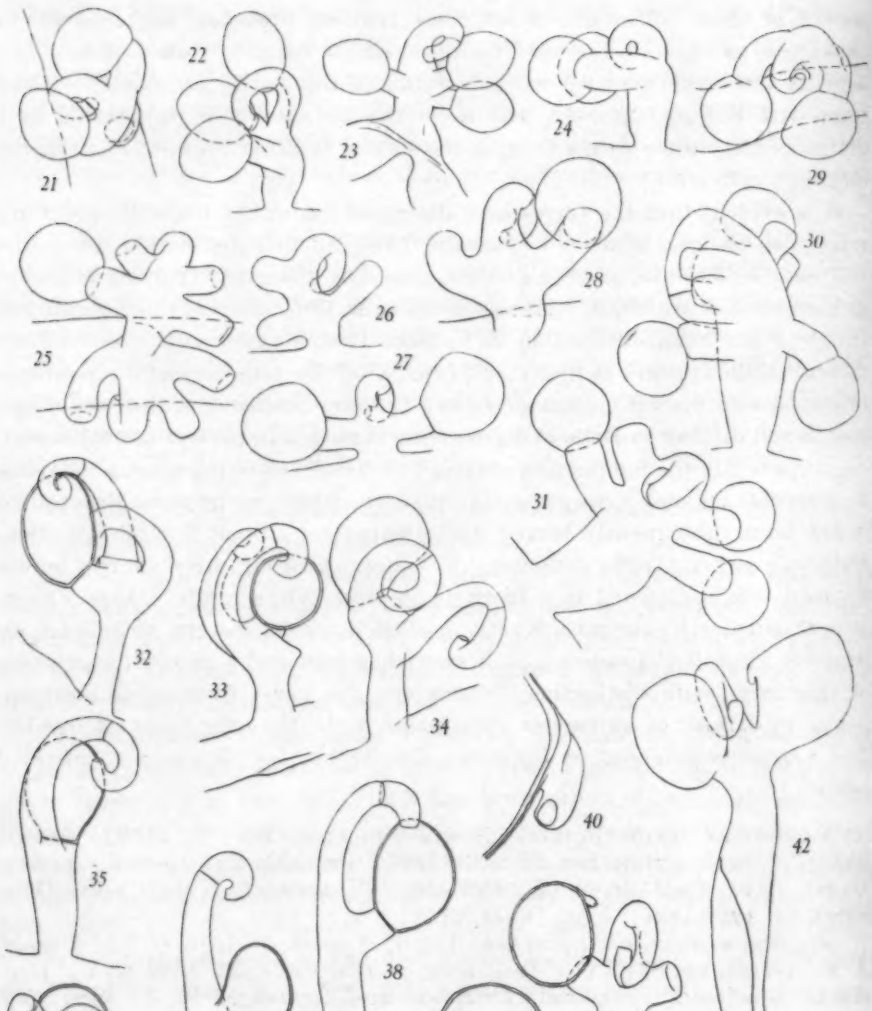
second of these collections shows some fruiting branches intermediate in character, so that a series of fruiting branches bearing from two to seven oogonia can be arranged if extreme forms of this entity are assembled and compared. Subsequent work may show the advisability of separating as a distinct entity those forms bearing the sort of fruiting branch found in the Sainteny collection.

It is evident that the forms here discussed under the name *V. walzi* are related on the one hand to *V. hamata*. The principal distinction lies in the fact that *V. hamata*, as here defined, possesses elongated fruiting branches at least some of which, in virtually every collection, bear only one oogonium. On the other hand, distinction of *V. walzi* from *V. geminata* is often more difficult than appears at first sight, because of the tendency of *V. geminata* to produce forms with much shortened fruiting branches, and of the aforementioned difficulty of observing fruiting branches in perfect lateral aspect.

Apparently the publication of Götz (1897) served to popularize the name *V. uncinata* in such a way that the plant to which he presumably applied it has been subsequently linked with this name without further question. Rothert's paper (1896) describing *V. walzi*, which appeared shortly before his own, was mentioned in a footnote by Götz, who stated: "Diese Vauch. stimmt mit der V. uncinata Kuetz. in allen Punkten überein, so dass ich sie letzterer zuzähle." Inasmuch as Rothert has provided a careful description of this form, with distinctive illustrations, the name *V. walzi* Rothert appears, in default of an earlier valid name, to be the only name applicable. The reader is referred to Rothert's description for details not provided below.

VAUCHERIA WALZI Rothert, Nuova Notarisia, Ser. 7: 81–82 (1896); Pringsh. Jahrb. f. wiss. Bot. 29: 530 (1896). Probably *Ectosperma racemosa* Vauch., Hist. Conf. 32 (1803). Probably "*V. uncinata* Kütz." *sensu* Götz, Flora 83: 122 (1897). Figs. 16, 17, 21–31.

Specimens examined: Sweden: Lund, *Agardh*, 8. 1816 (NY); Upsala, *J. E. Areschoug*, 8. (NY); Trelleborg, *Nordstedt*, 4. 22. 1882 (NY). Denmark: Sjaelland, Blouströdt, *L. Kolderup-Rosenvinge*, 10. 8. 1882 (T). Roumania: Ilfov, *E. C. Teodoresco*, (Krypt. exsic. 847, in part, NY). Germany: Schleswig (R); Connewitz, 4. 1857 (NY); Leipzig, 1858 (NY); Dresden, *Hantzsch*, 5. 1860 (Rabenh. Alg. Sachs. 979, NY); in fossa turfosa ad Waaghaüsel, *W. Schmidle*, 5. 16. 1894 (Wittr. & Nordst. Alg. exs. 1210, NY); Kützing's Alg. aq. dulc. Germ. 100, 12. 1833–34 (NY). Belgium: fossés, Bruges (Westend. & Wallays, Herb. Crypt. 244, in part, NY). France: fossés du marais, Sainteny, Manche, *Frémy*, 8. 16. 1920 (NY). Canada: in ditch near Snyder, Ont., *Blum* 634, 4. 19. 1951 (B). United States: *sine loco*, *N. L. Gardner* 956 (NY); in pond, Albion, N. Y., *Blum* 489, 5. 25. 1950 (B); in ditch near Sanborn, N. Y., *Blum* 656, 5. 10. 1951 (B); at Gulf Road, *ca.* two miles west of Conshohocken, Pa., *W. R. Taylor*, 5. 31. 1919 (T); Ardmore, Okla., *W. Kiener*, 1941 (Fl. North Amer. 12337a, C).



FIGS. 21–42. FIGS. 21–31. *V. walzi*. FIGS. 21–22. Kütz. Alg. Aq. Dulc. Germ. 100. FIG. 23. Rabenh. Alg. Sachs. resp. Mitteleur. 979, from Dresden. FIG. 24. Wittr. and Nordst. Alg. exs. 947b, from Montevideo. FIGS. 25, 26. From Albion, N. Y. FIG. 27. From Sanborn, N. Y. FIGS. 28, 29. Kiener's Fl. of North America 12337a, from Ardmore, Okla. FIGS. 30, 31. From Sainteny, France. FIGS. 32–38. *V. longata* sp. nov. FIGS. 32–34. From Karlsruhe. FIGS. 35, 36, 38. From Havre, France. FIG. 37. From Goes, Netherlands. FIG. 39. *V. undulata*, P. B.–A. 78b, from Morgan's Mills, R. I. FIGS. 40–42. *V. alaskana* sp. nov. From McKinley Park, Alaska. FIG. 40. Open oogonial beak and adjacent parts of oospore, ×700. All other figures ×150.

Fruiting branches of this species usually bear two or three oogonia which are similar in structure and appearance to oogonia of *V. hamata* (figs. 16, 17). The structure of fruiting branches which possess only two oogonia (figs. 21, 24, 27–29) is that of a shortened fruiting branch of *V. hamata*. When three or more oogonia are present, one or more of the oogonia are commonly borne at a level above or below the others (figs. 25, 26). This condition is not commonly found in *V. hamata*, and has never been observed in *V. geminata*. Fruiting branches bearing three or more oogonia in *V. walzi* usually take the form of a more or less bilaterally symmetrical corymb, with all the oogonia tipped in the same direction (figs. 25, 26, 30, 31). This is the only *Vaucheria* known to have a fruiting branch with this structure, and it is of interest to note that this form appears among the earliest illustrations of *Vaucheria*, those of Vaucher (1803), who figured such a branch for his species *Ectosperma racemosa*. From his descriptions it appears likely, however, that he identified and probably confused the form with the entity now generally known as *Vaucheria geminata* var. *racemosa* Walz. Fruiting branches of an elaborate corymbose type were likewise mentioned and inadequately described by Dupray (1887), but have apparently received no further notice, probably passing in most determinations for *V. geminata* which, it may be remarked, always has a radially symmetrical fruiting branch.

THE HAMATA-TERRESTRIS PROBLEM. Both in Europe and the United States *V. hamata* and *V. terrestris* are common plants. They are found in aquatic or subaerial habitats, and *V. hamata* is an almost ubiquitous soil alga in parts of northeastern United States. These species have often been confused due to their similarities, and this confusion has been augmented by the presence, at least in Europe, of a third entity, similar in appearance to the common *V. terrestris* but differing from it in certain subtle ways. This form is still too ill known to permit its definition.

There is a distinct difference in size between the two common species (Table 1), and specimens intermediate in habit or in size are rare. Space does not permit an exposition of the varied concepts of these species which have been subscribed to by phycologists of the past. Until the work of Dangeard (1939), few discriminating drawings of either species had been published; nevertheless it is generally possible to determine to which entity the various earlier authors had reference by consulting measurements which they report or by noting gross characters which are evident in their published illustrations.

Such unfortunately is not the case with Vaucher, the authority for the widely accepted names involved. His descriptions and figures afford evidence which, in the author's opinion, is in support of the contention that

Vaucher knew the larger, more usually aquatic species as *Ectosperma hamata*,[3] and the smaller, usually terrestrial species as *E. terrestris*. The evidence is, however, inconclusive, and as Vaucher's collections have apparently not been preserved,[4] the problem remains academic. The interpretation of the name "*V. terrestris*" as applicable to the larger species of the two has on its side the weight of usage by most of the recent phycologists.

TABLE 1. *Summary of contrasts between Vaucheria hamata and V. terrestris.*[2]

Character	*V. hamata*	*V. terrestris*
Habitat	common and widespread on moist soil, occasionally aquatic	usually aquatic, occasionally on soil
Size	relatively small	relatively large
Diameter of vegetative filaments	(24—)35—70(—100 μ) (B) 38.5—55.0 μ(G)	(45—)65—100(—110 μ) (B) 49.5—66.0 μ(G)
Thickness of wall, vegetative filaments	0.5—1.6 μ	1.0—2.0 μ
Width of mature oospore	(39—)50—60(—71μ) (B) 55.0—66.0μ(G)	(83—)90—125(—140 μ) (B) 60.5—99.0 μ(G)
Length of mature oospore	(45—)55—79(—86 μ) (B) 66.0—88.0 μ(G)	(87—)97—140(—150 μ) (B) 82.5—121.0 μ(G)
Thickness of oospore wall	1—2 μ	2—5 μ
$\frac{r_1}{r_2}$	3.0—5.0	1.5—3.0
Number of oogonia per fruiting branch	varies from one to two in virtually all collections	always one
Diameter of antheridium	12—21 μ	15—36 μ
Appearance of filaments when dried	usually wrinkled	usually unwrinkled
Color of filaments when dried	usually green	usually tan to pale brown

In view of the uncertainties involved and of the added confusion which would result from reversal of the determinations, as made by a score or more of phycologists of the past hundred years, the writer has decided to

[2] Other authors, including Götz, have mentioned various other contrasting characters in these two species; these characters include the gelatinization of the oogonial membrane in *V. terrestris* only and the formation of aplanospores in *V. hamata* only. While these characters may be valid, their validity cannot be attested to by the writer.

[3] It is stated by T. Christensen (personal communication), after a study of specimens in the Lyngbye herbarium, Copenhagen, that Lyngbye applied the name *V. hamata* to the larger of these species, a conclusion substantiated by Plate 20, Figure C of *Tentamen Hydrophytologiae Danicae* (Lyngbye, 1819), but that he used the name *V. terrestris* for what is now called *V. coronata* Nordst.

[4] Communication from Dr. Ch. Baehni, Geneva.

adhere for the present to the interpretation which is widespread in the literature, namely that of calling the larger species *V. terrestris* and the smaller *V. hamata*. It is evident that in the event that the collections of Vaucher are brought to light, it may become necessary to exchange the names as here employed, or to apply other names.

In the published data on these species, the dimensions vary markedly from author to author. The dimensions stated by Götz (G) are given in Table 1 for comparison with the average dimensions obtained by the writer (B). Of the many published descriptions of these species, those of Götz (1897) are among the most accurate, and most of the following remarks relating to *V. hamata* and *V. terrestris* are intended to be in amplification of the descriptions he has already provided. The procedure furthermore is adopted of designating the species in question as *V. hamata sensu* Götz and *V. terrestris sensu* Götz, omitting thus all references to the earlier authors, Vaucher, DeCandolle, Lyngbye, and Walz, who have used these names and been cited in various combinations as their authors.

VAUCHERIA HAMATA *sensu* Götz, Flora 83: 119 (1897). Probably *Ectosperma terrestris* Vaucher, Hist. Conf. 27 (1803). Probably *V. hamata* Walz, Pringsh. Jahrb. f. wiss. Bot. 5: 148 (1866). *V. hamata* (Vauch.) DC. in Dangeard, Botaniste 29: 200 (1939). Figs. 16, 17, 54–66.

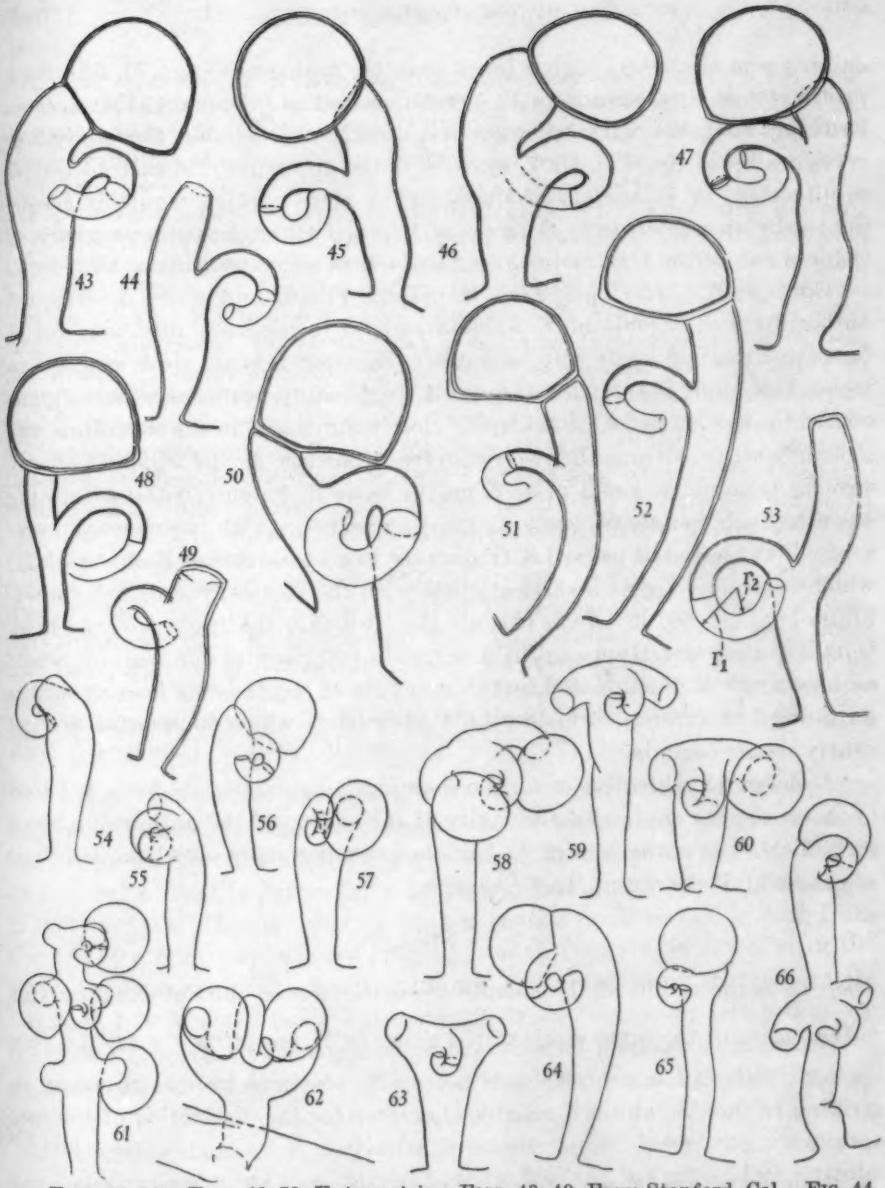
Specimens examined: Sweden: in a field between stubbles, Hven Is., *T. Christensen* 5357, 9. 2. 1951 (B). Germany: auf Schlamm am linken Elbufer, Dresden, *C. U. Hantzsch* (Rabenh., Alg. Eur. 1078, T); auf nackter Erde, Dresden, *C. U. Hantzsch* (*idem* 750, NY); Dresden, 6. 1859 (NY); Netherlands: Schore, Z.-Beveland, *B. J. J. R. Walrecht*, 4. 19. 1951 (R); Bij de Sloedam etc., *C. Brakman* 60, 11. 25. 1940 (R). France: Falaise, *De Brébisson*, 1840 (R); sur la terre humide des fossés aux environs de Havre, *Dupray*, hiver, 1887 (R); Desmazières, Pl. Cryptog. 260 (R). Canada: Grand Falls, N. B., *H. Habeeb* 10125, 1947 (C); *idem*, *H. Habeeb* 10129, 1947 (C); *idem*, springlet, lower basin, *H. Habeeb*, 7. 13. 1948 (M); Grand Falls, N. B., *H. Habeeb*, 1948 (Pl. Acadienses 13339, C). United States: Cambridge, Mass., *H. M. Richards*, 1889 (C); *idem*, *L. N. Johnson*, 1892 (C); greenhouse, New York Botanical Garden, N. Y. (NY); on mud near Niagara River, Hamilton Co., N. Y., *Blum* 566a, c, e, 10. 4. 1950 (B, C); in Mud Creek near Victor, N. Y., *Blum* 583, 10. 4. 1950 (B, C); on soil and cinders in greenhouse, Lackawanna, N. Y., *Blum* 609, 11. 19. 1950 (B, C); in ditch near Pekin, N. Y., *Blum* 658, 5. 10. 1951 (B); in springs southeast of Chestnut Ridge Park, Erie Co., N. Y., *Blum* 671, 5. 14. 1951 (B); on soil, Forest Lawn Cemetery, Buffalo, N. Y., *Blum*, 5. 15. 1951 (B); Cabin John, Md., *E. C. Leonard*, 1941 (Pl. of Md. 2865, C); Arlington, Va., *H. A. Allard*, 1939 (Pl. of Va. 6104a, C); Lake Iamonia, Fla., *F. Drouet et al.*, 1949 (Pl. of Leon Co., Fla. 11295, C); McIntosh, Fla., *F. Drouet et al.*, 1949 (Pl. of Marion Co., Fla. 11104, C); Tallahassee, Fla., *F. Drouet et al.*, 1949 (Pl. of Leon Co., Fla. 10471, C); in seepage springs, Univ. of Mich. Arboretum, Ann Arbor, Mich., *Blum* 765, 5. 16. 1952 (B, M); on soil two miles northeast of Saline, Mich., *Blum* 845, 9. 23. 1952 (B, M); greenhouse

bench, Univ. of Cincinnati, Cincinnati, O. (NY); Minneapolis, Minn., 1894, (Tilden, Amer. Alg. 44, C, NY); Purgatory Creek, Eden Prairie, Minn., *J. Tilden*, 7. 11. 1894 (*idem* 41, NY); Lincoln, Neb., *W. Kiener*, 1943 (Fl. of Neb. 13668, C); Lincoln, Neb., *W. Kiener*, 1941 (*idem* 10059, C); Lincoln, Neb., *W. Kiener*, 1941 (*idem* 9928, C); Ceresco, Neb., *W. Kiener*, 1943 (*idem* 13810, C); Fremont, Neb., *W. Kiener*, 1943 (*idem* 13882, C); Maywood, Neb., *W. Kiener*, 8. 28. 1941 (*idem* 11606, C); Inavale, Neb., *W. Kiener*, 1941 (*idem* 11969, C); Odessa, Neb., *W. Kiener*, 1944 (*idem* 17883, C); Waco, Neb., *W. Kiener*, 1944 (*idem* 17832, C); Utica, Neb., *W. Kiener*, 1948 (*idem* 24124, C); Ardmore, Okla., *W. Kiener*, 12. 28. 1941 (Kiener, Alg. Fl. U. S. A. 12337a, NY); floating on stream near Las Vegas, N. M., *F. Drouet* and *D. Richards*, 10. 16. 1939 (Fl. of San Miguel Co., N. M. 2589, NY); Oakland, Cal., *N. L. Gardner*, 5. 8. 1903 (NY); Santa Cruz, Cal., *L. Anderson*, 1884 (C); Oceano, Cal., *K. Hoppaugh*, 4. 15. 1927 (S). Alaska: Wiseman, *H. Croasdale* W-86V, 8. 17. 1951 (SI); on mud, McKinley Park, *H. Croasdale* 46a, 7. 10. 1951 (SI). Mexico: Guadalajara, *W. Kiener*, 1944 (Kiener, Pl. of Mexico 18102, C). Guatemala: Chimalt, *R. L. Wenzel*, 1948 (C). Uruguay: Montevideo, *Arachavaleta*, 1884–85 (Wittr. & Nordst. Alg. exs. 947a, b, NY, R).

Both the vegetative filaments and reproductive branches of *V. hamata* possess regularly thin cell walls. This causes the filaments to collapse and wrinkle markedly in the dried condition. Dried specimens of this species are also characterized by a greenish color which persists for many years, whereas in *V. terrestris* this color is quickly lost, so that the herbarium specimen, when unmixed with foreign material, becomes tan colored both in macroscopic and microscopic appearance.

The characteristic form of the fruiting branch of *V. hamata*, as illustrated by various authors of the last century, possesses two unbeaked oogonia and one circinate antheridium. The antheridium is terminal and median and curves off to one side or the other, while the two oogonia are attached by short pedicels which curve in the same direction as the antheridium and in such a way that the pores of the oogonia are more or less proximate to the antheridium. When these conditions are fulfilled, the specimen is clearly referable to this species, but in the absence of abundant fruiting branches and the presence of quite different types, identification becomes more difficult. Fruiting branches (figs. 54, 56, 57, 64, 65) much resembling those of *V. terrestris*, with a single oogonium, are found nearly as commonly in *V. hamata* as the type with two oogonia, and in some collections of *V. hamata* this is the only type present. Such fruiting branches seldom have an oogonial pedicel as long as those found on fruiting branches bearing paired oogonia (figs. 58–63).

Another common form of fruiting branch at variance with the classical concept is the result of one or more proliferations at the apex of an otherwise ordinary fruiting branch and the formation of other series of antheridia



FIGS. 43–66. FIGS. 43–53. *V. terrestris.* FIGS. 43, 49. From Stanford, Cal. FIG. 44. From Ultunaäsen, Sweden. FIG. 45. From North Java, N. Y. FIG. 46. From Java Center, N. Y. FIG. 47. Rabenh. Alg. Sachs. resp. Mitteleur. 495, from Constanz. FIG. 48. Rabenh. Alg. Sachs. 18, from Dresden. FIG. 50. From Vrads, Jutland. FIGS. 51, 52. From Lande de la Meauffe, France. FIG. 53. From Schleswig (type of *V. hamulata* Kütz.). FIGS. 54–66. *V. hamata.* FIGS. 54, 57. Kiener, Fl. of Nebraska 9928. From Lincoln, Neb. FIGS. 55, 56, 63. From Grand Falls, New Brunswick. FIGS. 58, 59. From Lackawanna, N. Y. FIG. 60. Kiener, Fl. of Nebraska 13810, from Ceresco, Neb. FIGS. 61, 62. Drouet, Pl. of Marion Co., Florida 11104, from McIntosh, Fla. FIG. 61. Fruiting branch which has proliferated twice, producing two additional series of antheridia and oogonia. FIG. 64. From Adams Lake, N. Y. FIG. 65. Drouet, Pl. of Taylor Co., Florida 10753. From Perry, Fla. FIG. 66. From Cambridge, Mass. Fruiting branch which has proliferated once. All figures × 150.

and oogonia at slightly higher levels than the first series (figs. 61, 66). Such proliferations are common in *V. hamata* as well as in various other species. Fruiting branches with extensive proliferations resemble the corymbose types described above under *V. walzi,* with the difference that each successive proliferation in *V. hamata* produces one or more oogonia regularly accompanied by an antheridium, whereas in *V. walzi* all of the pairs or whorls of oogonia except the terminal one or pair lack an accompanying antheridium.

Götz (1897), Heering (1921), Hoppaugh (1930) and others describe the antheridia and oogonia of *V. hamata* as bent in the same direction but as forming a distinct angle with each other. However it is not clear what orientation this angle is intended to possess. In fruiting branches with only one oogonium, the antheridium is usually closely appressed to the oogonium, and it is difficult to see how the two respective branches, one of which is greatly swollen terminally, could arise from the same dichotomy without forming a considerable horizontal angle. In fruiting branches with two oogonia, curvature of the oogonial pedicel is frequently in a horizontal or inclined plane, which inevitably forms a vertical angle with the vertically oriented antheridium (figs. 58–60, 62). Thus it is not clear whether the angle referred to by Götz, Heering and Hoppaugh is a vertical or horizontal one. In any event, such an angle is presupposed by the structure of the fruiting branch, and is duplicated in fruiting branches of *V. terrestris* which happen to possess nearly sessile oogonia.

A character which has not been mentioned by earlier students is based upon the degree of closeness or laxity of the coiling of the antheridium and its pedicel. The antheridia of *V. hamata* are much more closely coiled than are those of *V. terrestris.* In *V. hamata*

$$\frac{r_1}{r_2} = 3.0\text{–}5.0$$

where r_1 is the radius of the outside circumference of the antheridium and r_2 the radius of the inner circle of the same. In *V. terrestris* $\frac{r_1}{r_2} = 1.5\text{–}3.0$ (see fig. 53). This difference, although not easily observed by measurement, is striking to the eye, and is a reliable character for the distinction of the two species.

VAUCHERIA TERRESTRIS *sensu* Götz, Flora 83: 120 (1897). Probably *Ectosperma hamata* Vaucher, Hist. Conf. 26 (1803). Probably *Vaucheria hamata* Dec. in Lyngbye, Tentamen Hydrophytol. Dan. 77 (1819). Probably *V. terrestris* Lyngbye, Walz, Pringsh. Jahrb. f. wiss. Bot. 5: 149 (1866). *V. pendula* Reinsch, Algenfl. mittl. Theil. Franken: 221 (1867). Figs. 12, 13, 43–53.

Specimens examined: Sweden: Ultunaåsen, Bondkyrka Parish, Uppland, *G. Cedergren,* 5. 20. 1915 (Alg. Suec., C, NY); Upsala, *Anderssen,* 4. 1886

(NY); *idem, P. T. Cleve* (Aresch., Alg. Scandinav. exs. 178, C, NY). Denmark: on mud, near Vrads, Jutland, *T. Christensen* 4243–44, 8. 4. 1948 (B). Germany: längs des feuchten Randes und am Grunde eines periodisch mit Wasser gefüllten Grabens bei Vernheim in der Nähe von Mannheim, Hessen, 3. 23. 1893 (Schmidle, Phyk. univ. 578, NY); Reichsforst, Franconia (Type of *V. pendula* Reinsch, R; Rabenh. Alg. Eur. 1921, NY); Eilenburg, *Kützing* (R); Jever, Mars in fossis, *Koth* (Cotype of *V. hamulata* Kütz., R); Colmar, 1869 (NY); auf Leckern, Dresden, *L. Rabenhorst* (Rabenh. Alg. Sachs. 380, NY); in Gräben um Dresden (*idem* 18, NY); in Gräben, Maasbule, *L. Hansen* (NY); Karlsruhe (NY); Constanz, *E. Stitzenberger*, 11. 1855 (Rabenh. Alg. Sachs. 495 in part, NY). Holland: Goes, Zeeland, *R. B. van den Bosch*, "Vauch. circinata Kütz. 488" *ipse scripsit* Kützing (R); in ditches along the railway, Leiden, *J. H. Muhlenboer*, 4. 1847 (R). Belgium: fossés, Bruges (Westend. & Wallays, Herb. Crypt. 244 in part, NY); dans les fossés aux environs de Bruges (Desmaz. Pl. Crypt. 256, NY); France: Lande de la Meauffe, *Frémy*, 3. 2. 1921 (NY); Caen, Normandie, *Chauvin*, in part (R). United States: Woodbridge, Conn., *W. A. Setchell* 748, 4. 8. 1894 (M, NY); in swamp near North Java, N. Y., *Blum* 244, 4. 23. 1949 (B); Beaver Meadow, near Java Center, N. Y., *Blum* 624, 4. 6. 1951 (B); springs, sloughs, river, Iowa, *C. M. Hobby* (NY); ditch, Berkeley, Cal. (P. B.-A. 1288b, mixed in cotype material of *V. gardneri*, NY); Stanford campus, Stanford, Cal., *K. Hoppaugh*, 1927 (S). Alaska: seep in bank near Salt Lake, Barrow, *G. W. Prescott* Ba51 (P); pool near Salt Lake, one mile west of Barrow Laboratory, *G. W. Prescott* Ba55, 8. 17. 1951 (P); Vaucheria pool on tundra, Barrow, *G. W. Prescott* Ba-11, 8. 15. 1951 (P); Atka Is., *W. J. Eyerdam*, 7. 2. 1932 (M).

As with *V. hamata*, many of the standing descriptions of this species emphasize characters which are unclear or which are not always present. The frequent description of the oogonium as arising from the side of the antheridial pedicel is particularly confusing, inasmuch as the antheridium in this species is often or regularly seen to be on a small pedicel arising from the side of a relatively massive fruiting branch (figs. 44–46, 48–53). In the early development of the fruiting branch, the antheridium is temporarily terminal, but its small pedicel is so regularly and decidedly left behind by the upward growth of the oogonial pedicel that an unqualified statement of its position in ontogeny is not likely to give a true idea of its actual appearance.

The antheridium of *V. terrestris* is usually found below the oogonium, but sometimes is lateral to it, just as in those fruiting branches of *V. hamata* which bear a single oogonium. Due to its position, it is possible for the plane of the antheridium to coincide with that of the oogonium, and this is frequently the case. As noted by Dangeard (1939), however, this is too unreliable a character to use in determination (see above under *V. hamata*).

The statement of Collins (1909) and Hoppaugh (1930) to the effect that *V. terrestris* is commoner than *V. hamata* is likewise somewhat misleading.

Such a proposition appears highly doubtful, at least for eastern United States.

The type material of *V. hamulata* Kütz. consists in part of a form of *V. terrestris sensu* Götz with unusually long oogonial pedicels (fig. 53). Similar material has been seen in another collection (*Frémy,* Lande de la Meauffe), but intermediate specimens are numerous, and the differences do not seem adequate for the retention of the Kützing species.

Vaucheria brevicaulis Blum, Bull. Torrey Bot. Club 78: 445 (1951). Fig. 13.

This species is very closely related to *V. terrestris* as the latter name is here used. It is distinguished by the extreme shortness of the fruiting branch.

Vaucheria longata sp. nov. Filamenta 43–75 μ diam.; oogonia antheridiaque in pedicellis rami fructiferi peculiaris portata; ramus fructiferus unicum oogonium atque unum ad tria antheridia ferens, aut ramus fructiferus bifidus, duo oogonia, utroque unum antheridium vel plura habente, ferens; rami fructifera 140–345 μ altitudine; pedicellus antheridialis in ramo fructifero terminalis, parte basali longa, erecta aut paulum ab oogonio inclinata; parte superiore ad oogonium ita curvata ut apertura antheridii directe supra aut iuxta aperturam oogonii sit; antheridia circinata, unicam poram terminalem habentia. 16–20 μ max. diam. media in parte, in cacumine ad 10–11.5 μ attenuata; oogonia subovata, 56–74 × 83–102 μ, ad extremitatem pedicelli brevis, in basi pedicelli antheridialis lateraliter orientis, portata; oogonium quasi sursum versum, ad partem basalem pedicellorum antheridiorum interdum parallelum, oospora 55–73 × 82–100 μ, membranam tenuiorem habens (figs. 15, 32–38).

Filaments 43–75 μ in diameter; oogonia and antheridia borne on stalks of a special fruiting branch, with a single oogonium and 1–3 antheridia per fruiting branch, or the fruiting branch bifid, bearing two oogonia, each with one or more antheridia; fruiting branches 140–345 μ in height; antheridial pedicel terminal on the fruiting branch, its basal portion long and erect, or somewhat inclined away from the oogonium, its upper portion curved toward the oogonium in such a way that the opening of the antheridium is directly above or adjacent to the aperture of the oogonium; antheridia circinate, with a single terminal pore, 16–20 μ in their greatest diameter in the middle part, narrowing to 10–11.5 μ at the tip; oogonia subovoid, 56–74 × 83–102 μ, borne on the end of a short pedicel which arises at the base of the antheridial pedicel; oogonia directed nearly vertically, sometimes parallel with the basal portion of the antheridial pedicel or pedicels; oospore 55–73 × 82–100 μ, with a thin wall.

Specimens examined: Sweden: prope Upsaliam, *Cleve,* April (Aresch. Alg. Suec. 179, NY). Germany: Krottendorf (NY); in einem Graben an Wasserwerk, Karlsruhe (Migula, Krypt. Germ. Austr. Helv. exs. 49, NY, T). Holland: Zuid-Beveland, Goes, *Van den Bosch* (R). France: Type, eaux stagnantes d'une piscine, Le Havre, 1. 1887, (Dupray, Alg. des eaux douc. France 879, R).

This species was found in herbarium material filed as *V. geminata.* At first, its rather characteristic antheridial branches were interpreted merely

as unusually long for *V. geminata*. Then it was observed that five different European collections showed the same peculiarity, and in addition possessed apparently tilted oogonia which are more elongate than in *V. geminata*, *V. hamata*, and *V. terrestris*, the only species of circinate Vaucheriae with which this species is likely to be confused. The species approaches very closely, however, both in dimensions and in general appearance, *V. woroniniana* Heering, which possesses basically different antheridia.

As all the known material of this species is in the dried condition, measurements and observations on fresh or preserved material are lacking. Due to the inaccuracy inherent in measuring small angles on dried material, it is not possible to be certain as to the degree of inclination (from the vertical) of the oogonia. There seems little likelihood, however, that the oogonia are erect as in *V. geminata*, particularly as in *V. geminata* var. *racemosa*, and probably the actual degree of inclination is only somewhat less than in *V. terrestris*.

It is remarkable that this species has gone so long unnoticed. Undoubtedly it has been regularly mistaken for *V. geminata* or *V. terrestris*. Unless the observer is quite familiar with these other forms, a mistaken determination is easily made. Since in some collections it has been found mixed with *V. geminata*, its distinctiveness is then even less apparent than when it is growing alone, and this fact has no doubt contributed to its confusion with closely similar species.

Measurement of the ratio of the length of the oospore to its diameter provides one of the best characters for the distinction of this species. In *V. longata* this quotient averages 1.44. By comparison, averages of nine measured collections of *V. geminata* yield a quotient of 1.24, and in twenty measured collections (European and American) of *V. hamata*, a ratio of 1.17.

VAUCHERIA UNDULATA Jao, Sinensia 7: 741 (1936). Figs. 14, 39.

Specimens examined: United States: Morgan's Mills, Johnson, R. I., *W. J. V. Osterhout* (P. B.-A. 78b, C, M, NY, T); brook near Highland Ave., Malden, Mass., 4. 22. 1884 NY (R). Alaska: on soil, between Beetles Village and airfield, *H. Croasdale* B56a, 8. 9. 1951 (mixed in material of *V. alaskana*, B, SI).

This species was previously known from China (Jao, 1936; Ley, 1944). It resembles *V. terrestris* but possesses spiral vegetative filaments, and oogonia which are slightly smaller and which are also closer to being isodiametric, than in *V. terrestris* (fig. 14).

The North American material here reported exhibits somewhat larger oogonia (68–95 × 95–118 μ) than in the reported Chinese collections (62–74 × 71–84 μ), and fruiting branches are generally shorter in length than

those illustrated by Jao. These differences are not adequate, however, to warrant treatment of the American material as a different entity.

Species with an oogonial beak. At least three species related to *V. hamata* and *V. terrestris* possess distinct oogonial beaks. Of these three species, neither the original description of *V. adunca* Jao nor that of *V. pseudo-geminata* Dangeard gives any indication that the oogonia are inclined from the vertical position. Yet it is evident from the drawings of *V. adunca*, that such is the case for that species, and a study of dried material of *V. pseudo-geminata* indicates that the same may be true of the latter species as well. Therefore, both species are regarded tentatively as belonging to the group here considered; admittedly future research may very well show such a classification to be invalid. A new species, *V. alaskana*, is apparently related to the other two.

VAUCHERIA ADUNCA Jao, Sinensia 10: 150 (1939). Fig. 18.

This species is very similar to *V. hamata* in the structure of its fruiting branch, which is, however, unusually long. Its oogonia are distinctive: they are provided with a long, subcircinate beak about 30 μ in length (fig. 18); the oospore wall is described as thick.

VAUCHERIA PSEUDO-GEMINATA Dangeard, Botaniste 29: 214 (1939). Fig. 19.

Specimens examined: Hungary: auf der Erde bei den Pfaffentochers, Bösingerwald, *J. A. Baumler*, 8. 1910 (Fl. Posoniensis 613, T). United States: St. Mark's River, Newport, Fla., *F. Drouet et al.*, 1949 (Pl. of Wakulla Co., Fla. 10802, C).

This species, originally described from France, has recently been reported from Denmark (Christensen, 1952). In habitat and in general appearance it resembles *V. hamata sensu* Götz very closely, and undoubtedly has often been erroneously identified as that species. It differs from *V. adunca* in possessing a somewhat shorter beak, and apparently also in possessing shorter fruiting branches.

Vaucheria alaskana sp. nov. Filamenta 42–62 μ diam.; oogonia et antheridia in pedicellis rami frutiferi peculiaris portata; rami fructiferi 138–276 μ altitudine unum vel duo oogonia et unum antheridium ferente; pedicellus antheridialis in ramo fructifero terminalis, circinatus, inter duo oogonia lateraliter deorsumque deflexus, atque in antheridio circinato terminatus; antheridium 4 μ diam., poro terminali uno praeditum; pedicelli utriusque oogonii ad latus antheridiale rami fructiferi curvati, axe oogonii ad hoc latus, non verticaliter, aliquantulum inclinata, oogonia truncato-spherica, rostrata, 71–81 × 85–102 μ sine rostro; rostrum oogonii in latere antheridiali oogonii distaliter positum, ad basem oogonii abrupte flexum, 11–13 μ long, porus rostri ca. 3 μ diam. Oospora 70–80 × 84–101 μ, membrana duorum stratorum, tenui, sine colore. Figs. 20, 40–42.

Filaments 42–62 μ in diameter; oogonia and antheridia borne on pedicels of a special fruiting branch; fruiting branches 138–276 μ in height and

bearing one or two oogonia and one antheridium; antheridial pedicel terminal on the fruiting branch, circinate, bent laterally and downwards between the two oogonia, terminating in the circinate antheridium; antheridium 4 μ in diameter, with a single terminal pore; pedicels of both oogonia bent toward the same side as the antheridial branch; axis of the oogonium slightly inclined to the same side, not vertical; oogonia truncate-spherical, beaked, 71–81 × 85–102 μ without the beak; beak of the oogonium borne at the distal end, on the side adjacent the antheridium, reflexed toward the base of the oogonium, 11–13 μ in length, its pore approximately 3 μ in diameter; oospore 70–80 × 84–101 μ, its wall composed of two layers, thin and colorless.

Specimens examined: Alaska: Type, on soil, Beetles Village, *H. Croasdale* 312V, 8. 5. 1951 (SI, cotype in B, T); on soil in open woods, McKinley Park, *H. Croasdale* 151a, 7. 21. 1951 (B, SI); on soil between Beetles Village and airfield, *H. Croasdale* B56a, 8. 9. 1951 (B, SI).

This species, like *V. pseudo-geminata*, possesses an oogonial beak and otherwise greatly resembles *V. hamata sensu* Götz. The beak is much smaller than in *V. pseudo-geminata*, however, and is hooked to an unusual degree. In the dimensions of nearly all its parts, excepting the oogonial beak, *V. alaskana* is perceptibly larger than *V. hamata*, *V. adunca*, or *V. pseudo-geminata*.

VAUCHERIA ORIENTALIS W. and G. S. West, Ann. Roy. Bot. Gard. Calcutta VI, Pt. II: 184 (1907).

This *Vaucheria* (from Burma) is an undoubted member of the present group of species. It appears to have a distinctive habit, and is probably a distinct entity, although it resembles *V. hamata* rather closely. It is characterized by very small vegetative filaments (26–30 μ diam.) and very elongate fruiting branches, each apparently bearing a single sessile oogonium (50–54 × 65–67 μ) which appears from the published drawing to be somewhat more pear-shaped than in other species of the group. The oogonium lacks a beak.

VAUCHERIA PSEUDO-MONOICA Fritsch and Rich, Trans. Roy. Soc. S. Afr. 11: 322 (1924).

This species (from Natal) is characterized by fruiting stalks which bear numerous antheridia situated at various levels, solitary oogonia as in *V. terrestris sensu* Götz, and occasional septa in the filaments. The oogonia are intermediate in size (56–77 × 72–96 μ) between *V. hamata* and *V. terrestris*. The appearance of the fruiting stalk in the published figures suggests very strongly fruiting stalks of *V. hamata* or *V. terrestris* which have proliferated, producing at higher levels other series of antheridia and oogonia.

It is probable that still other species of *Vaucheria* of legitimate or doubtful status may eventually be shown to deserve a place among the species which are grouped in this paper on the basis of a tilting or inclination of their oogonia. At present, the evidence that their oogonia are tipped from

the vertical is lacking, and hence they are not here treated. Such species are *V. scrobiculata* Magnus and Wille and *V. amphibia* Randhawa.

Not all observed herbarium specimens of this group, moreover, are referable to species here outlined. It is probable that the group is larger than the present treatment would indicate, but in view of the paucity of collections of certain entities, they cannot at present be given adequate treatment. It is hoped that further study will bring to light additional collections of these evidently rarer forms, which will be sufficient to define them and to separate them clearly from the species treated in this study.

The species discussed in this paper may be segregated with the aid of the following key:

1. Oogonia subspherical, about 150 μ in diameter, entirely lacking a beak or prominence of any kind ..... *V. uncinata.*
1. Oogonia smaller and asymmetric, with a small distal prominence or a distinct beak ..... 2.
2. Antheridia usually elevated above the oogonia ..... *V. longata.*
2. Antheridia at level of, or below, the oogonia ..... 3.
3. Vegetative filaments spiralled ..... *V. undulata.*
3. Not so ..... 4.
4. Oogonia about 120 μ in length, each fruiting branch bearing only one oogonium ..... 5.
4. Oogonia less than 103 μ in length ..... 6.
5. Fruiting branches 220–560 μ in length ..... *V. terrestris sensu* Götz.
5. Fruiting branches 100–240 μ in length ..... *V. brevicaulis.*
6. Vegetative filaments more than 35 μ in diameter ..... 7.
6. Vegetative filaments about 17–33 μ in diameter ..... 9.
7. Oogonia lacking a distinct recurved beak ..... 8.
7. Oogonia possessing a distinct recurved beak which is visible after fertilization, open and empty, beyond the limits of the oospore ..... *V. alaskana* (Alaska).
8. Fruiting branch relatively long; each unproliferated fruiting branch possessing a single oogonium and one to many antheridia. *V. pseudo-monoica* (Africa).
8. Fruiting branch relatively long; each unproliferated fruiting branch possessing one to two, rarely three, oogonia, and only one antheridium ..... *V. hamata sensu* Götz.
8. Fruiting branch relatively short; each unproliferated fruiting branch possessing two or three or more oogonia and only one antheridium ..... *V. walzi.*
9. Oogonial beak to 30 μ in length, wide and subcircinate; oospore wall relatively thick ..... *V. adunca* (China).
9. Oogonia possessing a wide, recurved beak; oospore wall relatively thin ..... *V. pseudo-geminata.*
9. Oogonia lacking a beak ..... *V. orientalis* (Burma).

Acknowledgments. The writer expresses his sincere appreciation: to Dr. F. Drouet, The Chicago Natural History Museum, Dr. D. P. Rogers, The New York Botanical Garden, and Dr. Josephine Th. Koster, The Rijksherbarium, Leiden, for the loan of specimens without which the completion of this work would have been impossible; to Professor Wm. Randolph Taylor, who has read the manuscript and offered numerous helpful suggestions; to Dr. Hannah Croasdale for the preparation of Latin diagnoses; and to the following phycologists who have given valued help and provided specimens for study: T. Christensen, J. T. Conover, H. Croasdale, E. O. Hughes, G. W. Prescott, H. Silva, G. M. Smith, C. E. Taft, and L. E. Whitford.

DEPARTMENT OF BOTANY
UNIVERSITY OF MICHIGAN

Literature Cited

Christensen, T. 1952. Studies on the Genus Vaucheria I. A list of finds from Denmark and England with notes on some submarine species. Bot. Tidssk. **49**: 171–188.

Collins, F. S. 1909. The green algae of North America. Tufts Coll. Stud., **2**: 79–480.

Dangeard, P. 1939. Le Genre Vaucheria, spécialement dans la région du sud-ouest de la France. Botaniste **29**: 183–254.

De Toni, J. B. 1889. Sylloge Algarum Omnium Hucusque Cognitarum **1**: 393–408. Padua.

Dupray, L. 1887. Vaucheria des marais de l'embouchure de la Seine. Rev. de Bot. **5**: 336–354.

Götz, H. 1897. Zur Systematik der Gattung Vaucheria DC. speciell der Arten der Umgebung Basels. Flora **83**: 88–134.

Hansgirg, A. 1888. Prodromus der Algenflora von Böhmen. Prag.

Heering, W. 1921. Chlorophyceae IV. Siphonocladiales, Siphonales. Pascher's Süsswasserflora Deutschlands, Österreichs und der Schweiz. Jena.

Heidinger, W. 1908. Die Entwicklung der Sexualorgane bie Vaucheria. Ber. Deuts. Bot. Ges. **26**: 313–363.

Hoppaugh, K. W. 1930. A taxonomic study of species of the Genus *Vaucheria* collected in California. Am. Jour. Bot. **17**: 329–347.

Jao, C.-C. 1936. Studies on the freshwater algae of China II. Vaucheriaceae from Szechwan. Sinensia **7**: 730–747.

Kützing, F. T. 1856. Tabulae Phycologicae **6**. Nordhausen.

Ley, H.-H. 1944. The Vaucheriaceae from northern Kwangtung, China. Sinensia **15**: 91–96.

Lyngbye, H. C. 1819. Tentamen Hydrophytologiae Danicae. Hafniae.

Rabenhorst, L. 1863. Kryptogamen-Flora von Sachsen, der Ober-Lausitz, Thüringen und Nordböhmen. Leipzig.

———. 1868. Flora Europaea Algarum aquae dulcis et submarinae III. Lipsiae.

Rothert, W. 1896. Ueber die Gallen Rotatorie *Notommata Wernecki* auf *Vaucheria Walzi* n. sp. Pringsh. Jahrb. f. wissen. Bot. **29**: 525–594.

Teodoresco, E. C. 1907. Matériaux pour la flore algologique de la Roumanie. Ann. des. Sci. Natur. (Bot.) 9e sér., **5**: 1–155.

Vaucher, J. P. 1803. Histoire des Conferves d'eau douce. Genève.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, No. 6, pp. 498–499. NOVEMBER, 1953

NOTES ON TWO SMUTS REPORTED FROM THE UNITED STATES

MARVIN D. WHITEHEAD AND M. J. THIRUMALACHAR

1. PHYSODERMA MACULARE Wallr. *Ustilago alismatis* Ling. Lloydia 14: 101–110. 1951. In a recent paper Ling (1951) reported the occurrence of an *Ustilago* species parasitizing the leaves of *Alisma plantago-aquatica* L. collected by Garrett in Utah. The sori occurred as minute dark brown flecks on the leaves and petioles and measured up to 1.5 mm. in length; later becoming frayed and perforated due to the disintegration of the host tissues. The spores were subglobose to oval, golden-yellow, smooth and measured 27–39 × 21–31 μ but chiefly 28.5–36 μ in diameter. The fungus was identified by Ling as a new species of *Ustilago*.

Analysis of the spore measurements gave the authors the first indication that there might have been a mistake in the determination of the fungus. Normally in the case of smuts that have been studied on Gramineae, the species are ascribed to *Tilletia*, even in the absence of spore germination studies, merely on the basis of the spore measurements being more than 20 μ in diameter. On the other hand, if the spore measurements fall below 16 μ in diameter, the smut species are placed under *Ustilago*. These assumptions have usually proved to be correct in cases where germinations have been carried out at a later date. In *U. alismatis*, however, it was not clear why the smut was referred to *Ustilago* rather than to *Tilletia*, even though the spores measured 18 to 36 μ in diameter.

The type material of *U. alismatis* Ling deposited in the U.S.D.A. Mycological Herbarium, Bureau of Plant Industry, Beltsville, Maryland, was studied. Even though the material was collected in 1926 and hence quite fragile, thin sections were cut and examined. Observations showed that the fungus was not a smut but a species of *Physoderma*. The resting sporangia were large, intracellular (unlike the intercellular condition in the case of smuts) and developed within the cells of the epidermis and mesophyll tissue. They were golden-brown, ovate-elliptical and flattened on one side, which indicated the position of the lid characteristic of species of *Physoderma*. In some of the young resting sporangia the remnants of the rhizomycelium were observed. Comparative studies indicated that the fungus under study should be referred to *Physoderma maculare* Wallr. already known to occur on *A. plantago* in the United States (Karling 1950). This chytrid was previously mistaken for the smut *Melanotaenium*

by Cornu in 1883. *U. alismatis* Ling is offered as a synonym of *P. maculare* Wallr.

2. **Melanotaenium euphorbiae** (Lenz) comb. nov. *Tilletia euphorbiae* Lenz. Mycologia 33: 155–157. 1941. An interesting smut inciting spindle-shaped swellings on the stems and peduncles of *Euphorbia heterophylla* L. at Baton Rouge, Louisiana, was reported by Lenz (1941). The smut was placed under *Tilletia* as *T. euphorbiae* Lenz because the chlamydospores germinated as in *Tilletiaceae*.

Type material of the smut has shown certain interesting features. Sections through the sorus revealed that the spore mass was compacted in the cortex, forming a firm crust. Mature spores were dark brown in color and, due to close adpression with each other, were flattened on the contiguous sides. They measured 10–18 μ in diameter. Comparative studies indicated that the smut is a species of *Melanotaenium* and not *Tilletia*, resembling *M. endogenum* (Unger) DeBary and *M. hypogaeum* (Tul.) Schellenb. The sori in the latter are formed as swellings on the stems of *Linaria* sp. enclosing an agglutinated spore mass. The spores of *M. endogenum*, the type of the genus, measure 16–22 μ and germinate by the formation of 3 to 5 sporidia which conjugate *in situ* and form infection hyphae. The smut on *E. heterophylla* L. shows the same characters and is therefore placed under *Melanotaenium* by proposing the new combination *M. euphorbiae* (Lenz) Whitehead and Thirumalachar.

Department of Plant Physiology and Pathology, Texas A. & M. College System
College Station, Texas
and
Malleswaram, Bangalore
India

Literature Cited

Karling, J. S. 1950. The genus *Physoderma* (Chytridiales). Lloydia **13**: 29–71.
Lenz, L. W. 1941. A new smut from Louisiana. Mycologia **33**: 155–157.
Ling, Lee. 1951. Taxonomic notes on the Ustilaginales. Lloydia **14**: 101-110.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, NO. 6, P. 500 NOVEMBER, 1953

A NEW MELIOSMA FROM THE COLOMBIAN ANDES

JULIAN A. STEYERMARK

Meliosma bogotana Steyermark, sp. nov. Arbor 6-metralis, ramulis novellis et ad apices ramorum fulvo-velutinis vetustioribus glabrescentibus 1.3–2 cm. diam.; foliis simplicibus grandis abrupte petiolatis, petiolis 1.5–7 cm. longis 3–5 mm. diam. dense fulvo-tomentosis; laminis coriaceis elliptico-vel obovato-oblongis apice rotundatis vel abrupte cuspidatis, maturis 25–32 cm. longis 7–17 cm. latis, marginibus integerrimis vel juvenilibus grosse dentatis, supra maturis reticulatis secus costam mediam atque nervos laterales pilosulis ceterum glabrescentibus vel juvenilibus et ceteris pilosis subtus dense fulvo-pilosis, nervis lateralibus utroque 15–21 arcuato-adscendentibus ante marginem anastomosantibus; paniculis axillaribus 15–30 cm. longis 7–12 cm. latis, ramulis dense fulvo-pubescentibus; floribus sessilibus vel subsessilibus; sepalis 4 late ovatis obtusis 1 mm. longis 1.2 mm. latis imbricatis inaequalibus, extimo minore, marginibus ciliato-papillatis; petalis majoribus 3 late orbiculari-ovatis subobtusis cucullatis 2.5–3 mm. longis imbricatis glabris; petalis minoribus oblongo-ellipticis obtusis vel subacutis 2–2.5 mm. longis 0.7–1 mm. latis; staminibus fertilibus 2, ceteris 3 basi petalorum majorum ad squamas reductis sterilibus; staminium fertilium filamentis late linearibus 1 mm. longis, antheris 1.3 mm. longis; ovario tetragono biloculari 0.9 mm. alto, stigmate 4-partito, ovulis 4 vel 6.

Type locality: Quebrada de "El Chico," Bogotá, Dept. Cundinamarca, alt. 2750 m., September 25, 1946, *R. Jaramillo & J. M. Idrobo 451* (US, type; F).

Distribution: Known only from the quebradas originating from the *macizo* of Bogotá, Colombia.

Specimens examined: COLOMBIA: Quebrada de "El Chico," Bogotá, *Jaramillo & Idrobo 451* (US, type; F); bosque, Cordillera Oriental, extremo sudeste de la sabana de Bogotá, en San Miguel, Dept. Cundinamarca, alt. 2,800–3,000 m., Sept. 10, 1941, *J. Cuatrecasas & R. Jaramillo 12000* (US, F).

The better flowering specimen is found in *Jaramillo & Idrobo 451*, which I have selected as the type. In this collection the hairs on the upper surface of the leaf are quite dense, whereas in *Cuatrecasas & Jaramillo 12000*, a later stage of the same species, the upper leaf surface of the older and more mature leaves is glabrescent or much less pubescent and more reticulate than in the younger leaves of the type specimen. At first it was thought that the *Cuatrecasas & Jaramillo 12000* might possibly represent a different entity, but careful study of the material proves it to be only a later stage of the same species in more mature foliage.

The new species differs from *M. Schlimii* Urb. of Colombia in the denser pubescence of the lower leaf surface, petioles, peduncles, and branches of the inflorescence.

CHICAGO NATURAL HISTORY MUSEUM
CHICAGO, ILLINOIS
AND
MISSOURI BOTANICAL GARDEN
ST. LOUIS, MISSOURI

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, No. 6, pp. 501–506 NOVEMBER, 1953

A CYTOLOGICAL STUDY OF THE DEVELOPMENT OF GALTONIA CANDICANS DECNE[1, 2]

C. A. BERGER AND E. R. WITKUS

The normal occurrence of polyploid cell divisions during the development of diploid *Allium cepa* was reported in 1946 by Berger and Witkus. These divisions were found in the cortical cells of the transition region between root and shoot in seedlings 10 to 40 mm. long. The polyploid mitoses were tetraploid divisions with paired chromosomes. The polyploid divisions were most abundant in the seedlings 10 mm. long and as the seedlings increased in length, these divisions decreased in number until when the seedlings were 40 mm. long none were found. The divisions resembled those induced in large parenchyma cells through the use of growth hormones (Levan 1939, Berger and Witkus 1948). It was thought advisable to investigate the phenomenon in other members of the Liliaceae and the development of *Galtonia candicans*, the Summer Hyacinth, was studied. During the course of this investigation Holzer (1952) reported finding two tetraploid prophases in the hypocotyl of seedlings of this species.

Material and methods. Aceto-orcein smears and iron alum hematoxylin stained sections of the seedlings were prepared at various stages of development. In order to facilitate chromosome study the seedlings were treated with a 1% aqueous solution of colchicine for two hours before fixing.

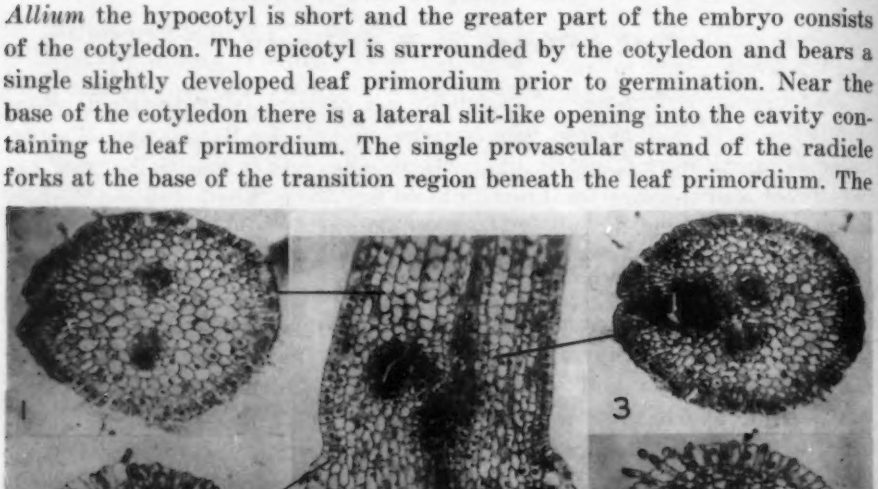
Observations and results. It was found that the development of *Galtonia* is very similar to that of *Allium*. As in *Allium cepa* polyploid divisions were found at a specific time in development. In *Galtonia* tetraploid divisions were frequent in seedings 8 mm. long. These 4n divisions were found in the large mesophyll cells of the cotyledon (figs. 1, 2) and in the cortex cells of the transition region between root and shoot (figs. 3, 4). No polyploid divisions were ever found in the root (fig. 5).

Galtonia candicans has the diploid chromosome number of sixteen. There are four large chromosome pairs, two medium sized pairs and 2 pairs of small chromosomes (figs. 6, 7). As pointed out by S. Nawaschin (1927) the large chromosomes are four to five times the size of the small chromosomes and the medium sized chromosomes are two to two and a half times the size of the small chromosomes. In the large cells of the dermatogen the chromatids of each chromosome are clearly separated (fig. 8).

[1] This investigation was supported in part by a research grant (PHS C-492 (C5)) from the National Cancer Institute, of the National Institutes of Health, Public Health Service.

[2] Illustrations published with the assistance of the Lucien M. Underwood Memorial Fund.

In *Galtonia candicans* the embryo within the seed appears as a rather straight cylindrical structure 3½ to 4 mm. long. There is a swelling directly below the transition region, which is due to an increase in the size of the cells in that area. This is particularly noticeable in the dermatogen cells. As in *Allium* the hypocotyl is short and the greater part of the embryo consists of the cotyledon. The epicotyl is surrounded by the cotyledon and bears a single slightly developed leaf primordium prior to germination. Near the base of the cotyledon there is a lateral slit-like opening into the cavity containing the leaf primordium. The single provascular strand of the radicle forks at the base of the transition region beneath the leaf primordium. The



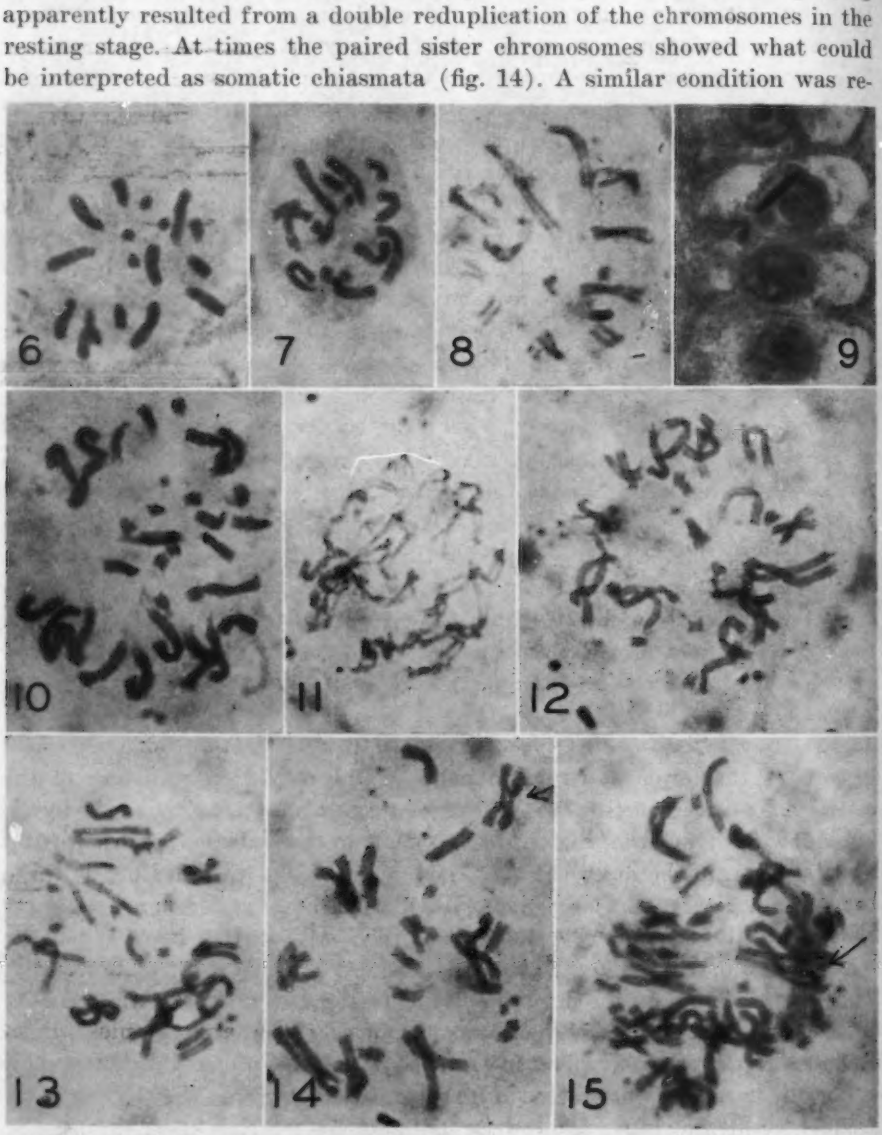
FIGS. 1–5. Photomicrographs of cross and longitudinal sections of young seedlings of *Galtonia candicans* (8 mm. long). ×50. FIG. 1. Cross section through the cotyledon 350 microns back from the base of the transition region. Note the two provascular strands. FIG. 2. Longitudinal section of the region of transition between root and shoot. FIG. 3. Cross section through the cotyledon just above the transition region. Note the first leaf primordium, the cotyledonary slit and the two provascular strands. FIG. 4. A section through the transition region and root, showing the large root hair cells and the smaller epidermal cells of the cotyledon. FIG. 5. Cross section through the root just below the transition region.

provascular strands then continue laterally up through the cotyledon. This is in contrast to the condition of the vascular system present in the transition region of *Allium cepa*. In *Allium* the single provascular strand of the radicle forks at the base of the transition region, but only one of the branches continues into the single cotyledon. The other branch continues into the first leaf primordium (Hoffman 1933). The cells of the provascular strands differ from the other cells of the embryo in their rectangular shape when viewed in longitudinal section.

All the cells in the embryo have prominent nuclear crystals, generally one to three rod-shaped crystals (fig. 9). These crystals stain black with iron alum hematoxylin but were not detectable in aceto-orcein smears. There is a direct correlation between the size of the crystal and that of the nucleus. The crystals appear to be present in the perinucleolar space. As the cells divide during germination, the crystals are evident until late prophase or early metaphase. After the first division, they are no longer found in actively dividing cells. The crystals persist in the cells of the dermatogen in the enlarged region of the root directly below the transition region. The cells in this enlarged region were never found in division. Nuclear crystals were previously reported in the cells of *Galtonia* by Leitgeb (1886). He found crystals in all parts of *Galtonia candicans* except in the underground portions of the roots and the bulbs. He claimed that these crystals were protein in nature and originated from the nucleolus. Leitgeb associated the crystals with the flowering of the plant. He stated that the farther away the tissue was from the flower the more sporadic the occurrence of crystals, but our observations do not confirm this statement. Digby (1910) noted crystalline bodies in the nuclei of the two outer rows of cells of the root of *Galtonia candicans* and especially in the outermost row. No crystals were found in the nuclei of the more rapidly dividing cells of the centrally placed tissue. The presence of an intranuclear crystal thus serves as a criterion for judging whether or not a cell has undergone mitosis in early germination. At the end of meristematic divisional activity the crystals reappear in the nuclei of the resting differentiated cells. A further study of these crystals is in progress.

In the germination of the seedling there is an initial elongation and growth of the lower and middle parts of the cotyledon resulting in the emergence of the root tip through the seed coat at the micropyle. The swelling below the transition region, first evident in the embryo, persists during germination and becomes the root hair region when the seedling is three to five millimeters long (figs. 2, 5). Until the seeding is 6–8 mm. long most of the growth is due to cell elongation principally in the shoot. When the seedling is 6 to 8 mm. long the root of the embryo begins to elongate rapidly. This growth is due to the mitotic activity of the root meristematic cells. At this time diploid divisions are common in the cotyledon and polyploid divisions are frequently found in the mesophyll cells of the cotyledon and in the corticel parenchyma cells of the transition region. They occur most frequently at a distance of between 350 and 770 microns from the base of the transition region. The polyploid divisions are chiefly tetraploid divisions (figs. 10 to 14). In only one instance was an 8n division detected (fig. 15). As the seedlings increased in length, the number of such polyploid divisions decreased and in seedings longer than 20 mm. such divisions were never

found. This is similar to the condition in *Allium cepa*. In the polyploid divisions the chromosomes were always paired (figs. 10 to 14). The pairing apparently resulted from a double reduplication of the chromosomes in the resting stage. At times the paired sister chromosomes showed what could be interpreted as somatic chiasmata (fig. 14). A similar condition was re-



FIGS. 6–15. FIGS. 6–8. Photomicrographs of aceto-orcein smear preparations of diploid cells from the shoot of *Galtonia candicans*. × 800. FIG. 9. Photomicrograph of a cross section through the root, showing a large nuclear crystal in one of the dermatogen cells. × 800. FIGS. 10–15. Photomicrographs of aceto-orcein smear preparations of polyploid divisions from the shoot of *Galtonia candicans*. × 800. FIGS. 10–14. Paired tetraploid divisions. Note somatic chiasmata evident in figure 14. FIG. 15. Octoploid cell showing the paired secondary association of sister chromosomes.

ported by Coleman (1950) in the cells of the stem of *Vicia faba* following treatment with indole-3-acetic acid. The apparent chiasmata in *Galtonia candicans* are probably not true chiasmata but are due simply to a relational coiling between sister chromosomes. The paired nature of the tetraploid divisions indicates that these cells divide only once as polyploid cells.

In all the seedlings studied only one octoploid cell was noted. This cell showed the secondary association of sister chromosomes. The chromosomes existed in groups of four, two pairs, the members of each pair relationally coiled (fig. 16) indicating that a quadruple reduplication of chromosomes had occurred between succeeding mitoses.

Discussion. In *Galtonia candicans* the presence of polyploid divisions may be associated with an auxin effect. It is well known that the same concentration of auxin has a different effect on the root and shoot. A very weak concentration of auxin will stimulate cell division and elongation in roots (Levan 1939). A strong concentration of auxin is necessary to stimulate shoot elongation and growth (Levan 1939), but this concentration inhibits root elongation. In *Galtonia candicans* the polyploid divisions occur in the large cortical cells of the transition and cotyledonary region during root inhibition. It is quite possible that until the seedling is 8 mm. long there is an accumulation of auxin in the seedling sufficient to inhibit root elongation while it stimulates the cortical cells in the shoot to divide and thus reveal their polyploid nature. A later decrease in the concentration of auxin might bring about the subsequent elongation of the root which occurs after the seedling has reached a length of 8 mm.

This assumption is further strenthened by the similarity between these naturally occurring polyploid divisions and those induced in resting differentiated cells when treated with growth hormones.

SUMMARY

1. In *Galtonia candicans* as in *Allium cepa* polyploid divisions were found to occur normally during development.

2. These divisions were commonly found in the cortical cells of the cotyledon when the seedling was 8 mm. long.

3. As the seedling increased in length, these divisions decreased in number. They were never found in seedlings longer than 20 mm.

4. The polyploid divisions were tetraploid divisions with paired chromosomes.

5. A single octoploid division was noted. This cell showed an association of chromosomes in groups of four.

6. The early development of the seedling was also reported.

BIOLOGICAL LABORATORY, FORDHAM UNIVERSITY
NEW YORK 58, N. Y.

Literature Cited

Berger, C. A. & Witkus, E. R. 1946. Polyploid mitosis as a normally occurring factor in the development of *Allium cepa L.* Am. Jour. Botany, **33**: 785–787.

Berger, C. A. & Witkus, E. R. 1948. Cytological effects of alpha naphthalene acetic acid. Jour. Hered. **39**: 117–120.

Coleman, L. C. 1950. Nuclear conditions in normal stem tissue of *Vicia faba.* Canadian Journal of Research C. **28**: 382–391.

Digby, L. 1910. The somatic, premeiotic and meiotic nuclear divisions of *Galtonia candicans.* Ann. Bot. **24**: 727–757.

Hoffman, C. A. 1933. Developmental morphology of *Allium cepa.* Bot. Gaz. **95**: 279–299.

Holzer, K. 1952. Untersuchungen zur karyologischen Anatomie der Wurzel. Öst. bot. Zeitschr. **99**: 118–155.

Leitgeb, H. 1888. Krystalloide in Zellkernen. Mitt. Bot. Inst. Graz **1**: 113–122.

Levan, A. 1939. Cytological phenomena connected with the root swelling caused by growth substances. Hereditas **25**: 87–96.

Nawaschin, S. 1927. Zellkerndimorphismus bei *Galtonia candicans* Des. und einigen verwandten Monokotylen. Ber. Deuts. Bot. Ges. **45**: 415–428.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, No. 6, pp. 507–514 NOVEMBER, 1953

STUDY OF TRICKLING FILTER FUNGI

C. W. HESSELTINE[1]

An extensive investigation of the fungus flora of trickling filter beds has never been made. An opportunity to study this problem was presented to the writer almost two years ago. At this time the Lederle sewage disposal plant was concerned with the functioning of their trickling filter beds, which are a part of the waste disposal system. These beds are constructed of crushed rock, over which intermittently a spray of liquid is showered, which then trickles downward over the surface of the rocks with the resultant reduction of the organic materials in solution. Although conditions throughout the filter bed should be aerobic, because of overloading they often become partially anerobic with the consequent variation in the microbiological life. In order better to understand the variable nature of the efficiency of the beds, it was requested that a microscopic examination of the microorganisms adhering to the rocks be made. It was realized, of course, that life here might be very different from that seen on beds receiving domestic wastes. This difference arises from the nature of the large amounts of antibiotic wastes and the presence of variable amounts of solvents, alkalis, acids, etc. passing through the system. At the same time there would be variable amounts of oxygen available to the microflora. Since late in 1950, samples in the form of stones removed from three different positions on the beds have been studied each month. In each sampling one stone is taken at the surface of the margin of the bed where only a small amount of sewage is deposited. A second stone is taken from the top of the bed, which is periodically receiving a load of waste. The third sample is removed from the center of the bed but taken a distance beneath the surface where conditions often are far from being aerobic.

From the beginning it was apparent that among the microscopic organisms in the beds a considerable amount of living fungus mycelium was present, which must play a part in the economy of the oxidation process (fig. 1). After seeing the beds during a year's period, it has become apparent that fungi were constantly a regular portion of the flora. In this time, aside from some of the higher filamentous bacteria, it was found that the fungi which are living inhabitants of the beds during the seasons of the year fall into but three species. These can be recognized when they occur in large quantities, as they do on the beds, by their distinct colony appearance, diameter of the mycelium and the spores which each form there.

[1] Present address: Northern Regional Research Laboratory, Peoria, Illinois.

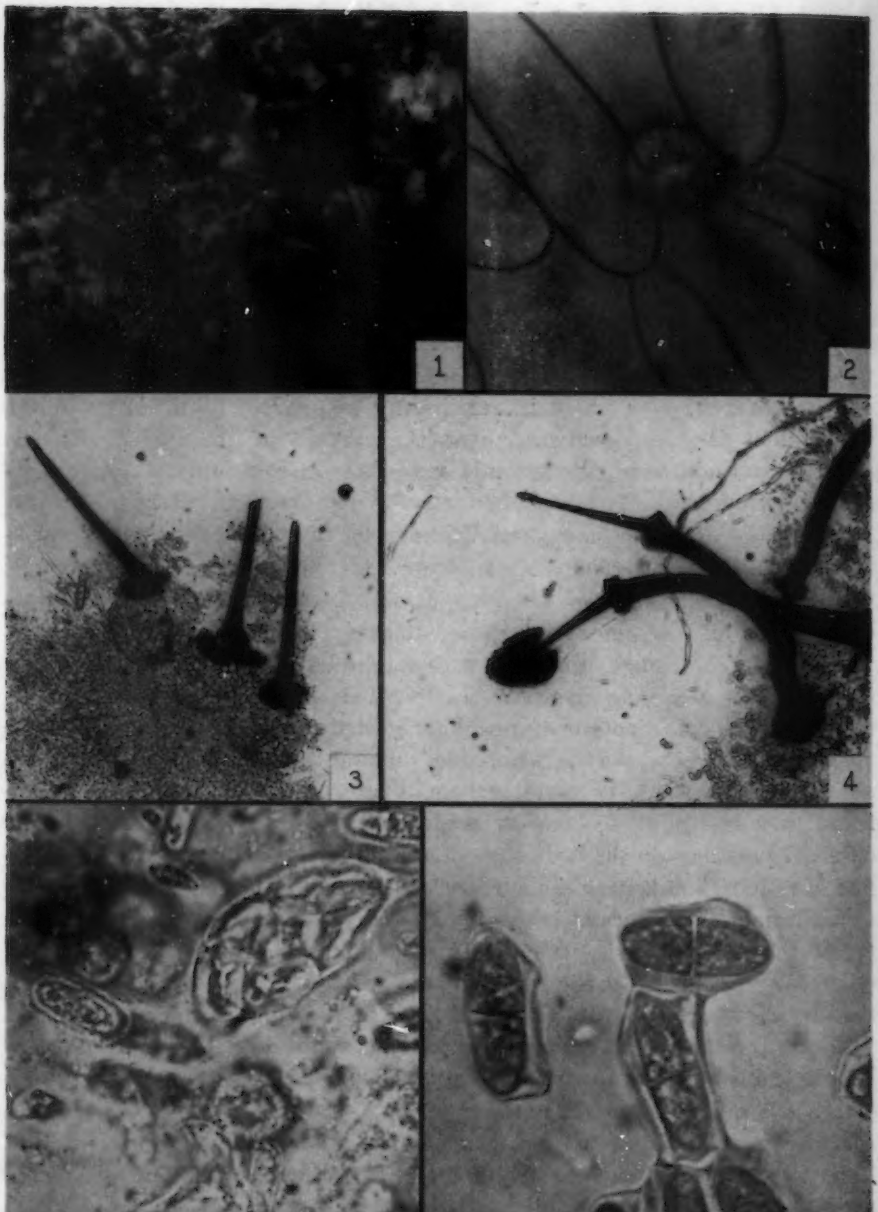


FIG. 1. A photograph of a stone from a trickling filter bed showing adhering film of fungi, xl. FIG. 2. Conidia formed on yeast extract agar in pure culture. FIG. 3. Immature perithecia. FIG. 4. Mature perithecia showing the distinct collar and with ascospores extruded from the ostiole. FIG. 5. Asci. FIG. 6. Ascospores.

Examination of the rocks was made by scraping off portions of the adhering slime and examining it under a microscope. All these examinations were made immediately after the samples were received in the laboratory. This was particularly important in the study of the microfauna, which rapidly change with standing in the laboratory. In the case of fungi numerous isolations were made from hyphae removed from the stones.

Besides these three fungi, plates often showed other molds, which were considered to be present only as chance contaminants and to be of no importance in the biological oxidation process. This was based on the observation that they were not regularly isolated and that never was any growing mycelium seen on the rocks which did not prove to be the three forms discussed below.

FUSARIUM EPISPHAERIA. The first of these three fungi is *Fusarium episphaeria*, which is readily recognized by its yellow-orange, moist masses attached to the stones. Upon microscopic examination these colonies taken from the stones showed an abundance of septate macroconidia of the genus *Fusarium*. At times it has become so abundant on the rocks at the surface of the trickling filter system that the beds take on a dull reddish color particularly at their edge. Apparently it is strictly aerobic, since it is always seen on the exposed surface of the rocks or at only slight distances below the surface of the beds. There is some indication that it may be seasonal, since the largest amounts seem to be present in the spring, summer, and fall months and somewhat reduced during the winter. It is often seen associated with the *Chlorella* cells, which are on the exposed stones during the warmer months of the year. What the relationship may be between these organisms is not known.

The positive identification of this fungus as *Fusarium episphaeria* (Tode) Snyder and Hansen was made by Dr. William C. Snyder. This fungus has been reported from sewage previously under the name *Fusarium aquaeductum* (Butcher 1932).

OOSPORA LACTIS. The second fungus appeared to be more abundant in the cooler months of the year. It appeared as grayish, mucus-like masses of mycelium, which were found on the surface of the beds and also some distance beneath the surface. As with *Fusarium*, this species could be readily isolated in pure culture. In pure culture spore production was not unlike that of *Streptomyces* in that large portions of the aerial mycelium were converted into chains of spores. Interestingly during the winter direct microscopic examination of the fungus showed no conidia in the masses of mycelium. However, if the stone with the mycelium was allowed to stand at room temperature for a short time, much of the mycelium was converted into spores. As the weather became warmer, however, conidia could be found on freshly collected stones.

Two isolates of this fungus were sent to Dr. Wickerham of the Northern Regional Laboratory, who kindly identified them as *Oospora lactis* (Fres.) Sacc. (*Geotrichum candidum*). This fungus has been previously reported from sewage (Reynoldson 1942).

Subbaromyces splendens. The third fungus was unlike these two species in that little was seen of its growth at the surface of the beds, but one did find it occurring abundantly on the underside of the stones at the surface of the bed. It was seen, likewise, from samples taken from deep down in the beds where conditions, as proved by the odor and corresponding absence of microfauna, indicated a reduced oxygen environment.

The fungus occurred as blackish masses of mycelium in which large quantities of inert material were held. These masses of fungus growth were adherent and cottony, appearing as pieces of badly soiled, soggy, wet cotton. When examined microscopically, an extremely stout mycelium (often up to 19 μ in diameter) was seen, which, although hyaline at the growing portion, became quite darkened in the older regions. Attached and floating free were large ellipsoid, one-celled conidia. It was apparent that this fungus was occurring in considerable quantities and often appeared to enhance the accumulation of sludge between the rocks of the bed, which in turn results in ponding.

Attempts were made to isolate this fungus in pure culture. Masses of the mycelium taken from rocks showing only this fungus present were washed and placed on nutrient agar plates. It was while proceeding with this work that it was noted that ten to twelve days following the placement of a mass of mycelium on an agar plate the beaks of an ascomycete appeared from the surface of the mycelium placed on the agar from the stones. Since then this procedure has been repeated again and again, always with the same results, provided that nematodes do not become so numerous that the entire material is destroyed. Fruiting thus occurs in mixed cultures with bacteria and protozoa. Fruiting may occur only at the site of inoculation with mycelium from the stones or in other cases on the surface of the agar. In no instance have perithecia been produced in pure culture. It seemed almost certain that the perithecia were the perfect stage of the mycelium taken from the stones. This is based upon the following facts. The mycelium attached to the perithecia was of the same appearance and size as that seen in nature. Conidia produced on filaments attached to the perithecia were similar to those seen in the beds. Lastly, ascospores, which could be readily picked from the ostioles of the perithecia, were placed on nutrient agar and pure cultures obtained. These colonies showed mycelium of the same size and the same mode of branching as seen on the stones. The conidia produced from these cultures isolated from ascospores were identical with those seen on the trickling filter beds.

A search of the literature failed to reveal any description of this organism except for a report of Haenseler, Moore and Gaines in 1923. These investigators apparently studied the conidial stage of this fungus and clearly illustrated it. However, they only referred to it as Fungus No. 1. For the perfect stage it even seemed doubtful if there were a genus to which it could be assigned. Accordingly, it is proposed that a new genus, *Subbaromyces*, be erected and that its type species be named *Subbaromyces splendens*, because of its extremely spectacular form. The name *Subbaromyces* is proposed to honor Dr. Y. Subbarow, former director of research at Lederle Laboratories, whose keen interest in the activities of the fungi has been a constant source of inspiration to the author.

Subbaromyces gen. nov. Perithecia ex parte submersa, demum superficialia, membranacea, globosa longe rostrataque, rostro in partes duas e collari grandi conspicuo diviso, parte superiori ad ostiolum parvum hyphis fimbriatis circumdatum attenuata; asci mox evanescentes, clavati, octospori; paraphyses carentes; ascosporae hyalinae, in cellas duas aequales divisae, tunica gelatinosa vestitae, ut guttula mucosa ad apicem perithecii extrusae; conidia unicellularia, ordinatim et exogene oriunda.

Perithecia partially submerged, later superficial, membranous, syringe-shaped, beak divided into two portions by a large pronounced collar, with upper portion tapering to a small ostiole, surrounded by a fringe of hyphae; asci soon autodigested, clavate, 8-spored; paraphyses absent; ascospores hyaline, 2-celled, cells equal, surrounded by a gelatinous envelope, extruded as a mucus-like droplet at tip of perithecium; conidia 1-celled, formed successively exogenously.

Subbaromyces splendens sp. nov. Perithecia membranacea, 1–2 mm. alta, basi bulbosa 165–275 μ in diam., collari 132–192 μ in diam.; rostrum supra collarem 330–575 μ longum, 16–60 μ latum; asci octospori, 36–62 $\times$ 12–27 μ; ascosporae bicellulares, hyalinae, tunica gelatinosa vestitae, 18–24 $\times$ 5–9.5 μ; conidia unicellularia, hyalina, exogena, in cultura 31–52 $\times$ 11–15 μ.[2]

Colonies on yeast extract and potato dextrose agar translucent, with most of the mycelium in the substrate, only visible aerial mycelium at the center of inoculation or in very old cultures; mycelium hyaline, vacuolate, septate, with hyphal branches formed beneath the septa, often slightly swollen just beneath the septum and with conspicuous granules on either side of the septum, hyphae measuring 8.5–12.5 μ in diameter; conidia borne successively from the ends of hyphae resulting in several conidia lying together as each is displaced by the next, but not in chains; conidia smooth-walled, exogenously formed, hyaline, granular, ellipsoid, one-celled, showing a slightly flattened region at the location of attachment to hypha, 31–52 $\times$ 11–15 μ, typically 36–43 $\times$ 13.5 μ (fig. 2).

Perithecia (in mixed culture on agar) membranous, dark-colored, smooth-walled, at maturity 1–2 mm. in length (figs. 3 and 4), at first partly submerged, then mostly erumpent, "syringe-shaped" with bulbous base 165–275 μ in diameter, with an extremely long beak divided into two portions by a collar 132–192 μ in diameter; the beak below the collar 66–126 μ

[2] The author wishes to thank Edith K. Cash for translating the diagnoses into Latin.

in diameter, the beak above the collar 330–575 μ in length, varying in diameter from 44–60 μ just above the collar to 16–27 μ above; ostiole surrounded by a series of long light-colored hyphae which are 40 μ in length and which are free with their ends acute; paraphyses absent; asci formed before the complete elongation of the beak, clavate, stipitate with their walls rapidly undergoing autodigestion, 36–62 × 12–27 μ, with 8 tightly packed, irregularly arranged ascospores (fig. 5); ascospores smooth, ellipsoid, with 2 equal cells, surrounded by a gelatinous envelope as much as 6 μ in thickness, 18–24 × 5–9.5 μ (fig. 6).

Mycelium from trickling filter rocks hyaline, later often quite dark, forming conidia as above but somewhat more variable in size than when formed in culture.

This fungus was found repeatedly growing on trickling filter beds, Pearl River, New York. The growth of mycelium is typically below the surface of the bed where the oxygen present may be considerably reduced.

Type material has been deposited at the New York Botanical Garden and with the U. S. Herbarium, U. S. Department of Agriculture.

When a portion of the mycelium of this fungus was taken from a stone and placed on yeast extract agar in a Petri dish, fruiting occurred in seven to ten days. In some cases other fungi or worms may mask or destroy the culture. When first seen, the perithecial stage appears as small fruiting bodies whose light-colored bulbous bases are submerged except for their dorsal surfaces beneath a beak. The beaks, as contrasted to the bulbous base at this stage, are black and project stiffly from the substrate. The collar, which later divides the beak into two portions, is not apparent. When perithecia are carefully dissected from the mycelium and gently crushed, asci can be readily demonstrated. The asci are thin-walled, broadly clavate, and possess a short stipe. Apparently the asci very soon undergo autodigestion, for freed ascospores can also be found. During or perhaps even after completion of ascospore formation the region just below the beak continues to grow and elongate so that the portion of the beak seen at the time of ascospore formation is carried upward and marked by a distinct region, which appears as a shield or collar. The larger portion of the beak below this collar, therefore, is formed during or after the formation of the ascospores.

When the perithecium has reached its maximum size, the beak is marked by a longer, broader portion surmounted by a collar. Above the collar the second portion of the beak is shorter in length and smaller in diameter and, as mentioned above, was formed earlier. The beak with the bulbous base of the perithecium therefore takes on the appearance of a syringe. Hundreds of perithecia have been seen, and each at maturity possesses this characteristic form. At the time the beak has reached maturity, a whitish gray mass of ascospores is seen extruded from the ostiole where they remain as a droplet. At this time the entire perithecium is blackish in color including

the bulbous base. The entire perithecium now appears to be above the surface of the substrate. In fact they seem to be top-heavy, for often some will be seen which have toppled over onto the surface of the medium.

When ascospores were isolated from the tip of a perithecium, pure cultures could often be obtained. In pure culture the growth of this species is very characteristic, since it forms all of its vegetative mycelium below the surface of the medium, and only where fruiting hyphae are formed is there any aerial growth; hence, the culture appears much as *Pilobolus* in culture. After several weeks some aerial mycelium is seen at the point of inoculation. Branches arise characteristically just below a septum, which is usually marked by the presence of a few conspicuous granules on either of its sides. The conidia are formed just as they are seen in the filter bed. As observed on yeast extract agar, a hyphal tip produces a swelling, which assumes an ellipsoid shape and then is separated from the hypha by a septum. A number of spores are produced successively in this manner, but instead of a chain, probably because the spores are in contact with the agar when formed, several are seen lying parallel to each other. The conidia are quite large, measuring up to 50 μ or more in length. No endogenously formed conidia were ever seen.

The ascospores as contrasted to the conidia are surrounded by a hyaline gelatinous sheath and are two-celled. The two cells are equal in size.

It is obvious because of the manner of ascospore formation, the nature of the long beak, the lack of paraphyses, etc. that it definitely belongs in the family Ophiostomataceae where *Ceratostomella* is placed. However, in *Subbaromyces* the ascospores are not single-celled but are regularly divided by a septum. As far as the writer is aware, no genus has been described with the distinct collar or shield which sharply divides the beak of the perithecium into two portions.

The genus *Spumatoria* Massee and Salmon described in 1901 possessed perithecia which had two-celled ascospores. However, in this genus the spores are smaller in size, and the ascospores are formed in almost a linear series in a cylindrical-shaped ascus which did not undergo autodigestion. The appearance of the beak was entirely different.

SUMMARY

1. Microscopic examination of the fungus flora of a series of trickling filter beds over a period of two years indicated that only three species of fungi were present as regular inhabitants.

2. The first two were readily determined as *Fusarium episphaeria* and *Oospora lactis*. Each seems to be somewhat seasonal in its growth.

3. The third fungus appears in the conidial form on the beds, but when

grown on nutrient agar in mixed culture proved to be a new genus and species of the family Ophiostomataceae.

4. The generic name proposed for this fungus is *Subbaromyces* with the type species designated as *S. splendens*.

LEDERLE LABORATORIES DIVISION, AMERICAN CYANAMID COMPANY
PEARL RIVER, NEW YORK

Acknowledgments. The writer wishes to acknowledge the aid of Mr. J. G. Niedercorn, Mr. J. M. Brown and associates, who supplied the samples from the trickling filter beds. He wishes to particularly thank Dr. Julian Miller of the University of Georgia for examining some of the slides of the fungus described here and for certain other helpful suggestions. He is also indebted to Mr. Leslie McWilliams for the photographic work. Likewise, he wishes to express his appreciation to Lederle Laboratories for permission to publish this paper.

Literature Cited

Butcher, R. W. 1932. Contribution to our knowledge of the ecology of sewage fungus. Trans. Brit. Mycol. Soc. **17**: 112–124.

Haenseler, C. M., Moore, W. D., & Gaines, J. G. 1923. Fungi and algae of the trickling filter bed with special reference to their seasonal distribution. New Jersey Agr. Expt. Station Bull. **390**: 39–48.

Massee, G. & Salmon, E. S. 1901. Researches on coprophilous fungi. Ann. Bot. **15**: 313–357.

Reynoldson, T. B. 1942. Further studies on the biology of a double filtration plant at Huddersfield. Jour. and Proc. Instit. Sewage Purification (London) 116–134.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 80, No. 6, pp. 515–517 NOVEMBER, 1953

TORREYA

MILLSPAUGH'S FOOTSTEPS RETRACED AFTER SIXTY-NINE YEARS

J. HARRY LEHR

In 1884, Charles Frederick Millspaugh made a report to the Torrey Club on the orchids and sundews of Spruce Pond, N. Y. His list contained the following species: *Habenaria psycodes, H. hyperborea, H. dilatata, H. blephariglottis, H. lacera, Calopogon pulchellus, Microstylis monophyllos* (*Malaxis brachypoda*), *Aplectrum hyemale, Cypripedium arietinum, C. candidum,* and *C. spectabile* (*C. reginae*). The two sundews listed were *Drosera rotundifolia* and *D. longifolia* (*D. intermedia*). The middle of June was specifically mentioned as the most opportune time to visit the area.

Although the pond is now part of the Palisades Interstate Park system its location is far from the popular sections and it is rarely visited even by hikers. There is a Boy Scout camp on the eastern shore of the pond but the scouts are only seen in the bog during blueberry-picking time. In view of these facts a combined group from the Torrey Club and the Rockland Audubon Society made an exploratory field trip into the area on Sunday, June 14, 1953, in an effort to relocate some of the species in Millspaugh's report.

Because of the rugose nature of the bog, the group was divided into two units. One unit explored the bog proper while the other explored the borders. The entire extent of the bog was scoured but the only orchid found was *Pogonia ophioglossoides,* which was not mentioned by Millspaugh. Both sundews were found and in addition the unit located plants of interest in other genera including *Kalmia polifolia, Nemopanthus mucronata, Andromeda glaucophylla, Menyanthes trifoliata* and both of the cranberry species. It was the considered belief of the group that failure to locate any of the orchids on the list could be attributed to the fact that in the years since Millspaugh's visit what was then an open bog has become a shrub thicket, in many places reaching almost to the water's edge. Nevertheless, *Sarracenia* has remained abundant.

Meanwhile the second unit, exploring the fringe of the bog, had reported three orchids which were not found on the bog nor on Millspaugh's list: *Cypripedium acaule, C. Calceolus,* and *Goodyeara pubescens.* Why did Millspaugh omit these? Were they too common to be considered among his rarities or did he confine his list to those species of the more acid bog proper? The second alternative appears more likely since he reports spending only an hour between trains on the bog and did not himself see the three species of *Cypripedium* that are not on his list.

The original task of this unit had been the confirmation of a fern list from the same area reported by Archibald Shorey (1928). Of the twenty-one common species listed all but *Athyrium thelypterioides* were located on this trip. In addition, the list was increased by two species: *Botrychium dissectum* forma *obliquum* and *B. matricariaefolium.*

MONSEY, N. Y.

Literature Cited

Millspaugh, C. F. 1884. The Droseraceae and Orchidaceae of Spruce Pond, N. Y. Bull. Torrey Club. **11**: 133–134.

Shorey, Archibald. 1928. Ferns of Spruce Pond, Southfields, N. Y. Torreya **28**: 112–113.

FIELD TRIP REPORTS

May 31. Salisbury, Conn. Joint meeting as guests of Connecticut Botanical Society. Feature of the day was the beautiful and very scenic Sages Ravine close to the Connecticut-Massachusetts line on Route 41. This is a wild, wooded gorge having a rigorous brook with many cascades. The trees are huge hemlocks and northern hardwoods. The

rock formation was schist and limestone, in which many pot-holes were investigated. The ruins of an early colonial iron furnace were seen at a distance; the district known as Hammertown. Many plants of *Orchis spectabilis* were found, mostly past bloom, in an area of flooded iron-ore bed pits. Herbarium material was collected by Rev. Jesse F. Smith of Suffield Academy and Prof. G. S. Torrey, Univ. of Connecticut. Mr. Leonard J. Bradley of Audubon Nature Center, Greenwich, prepared a list of noteworthy plants from Sage's Ravine. Attendance 45. Leader, Walter P. Green.

June 14. Spruce Pond, N. Y. See Millspaugh article above. Attendance 17. Leader, J. Harry Lehr.

June 16–19. The Seventh Annual Field Excursion of the Northeastern Section of the Botanical Society of America was largely Torrey Club members who enjoy studying the natural vegetation of characteristic areas in the range. The success and pleasure of the foray is credited with thanks to the corporation of Baum, Ogden, Smith & Winne. A report of plants seen and other pertinent data is reported to be available from Stanley Smith, The State Museum, Albany, N. Y. Four characteristic areas were studied. The Sand Plains vegetation may be illustrated by *Ceanothus ovatus, Houstonia longifolia,* and *Potentilla arguta.* In the Dead Sea area *Salix pyrifolia* and *Smilacina trifolia* are representative. The Flat Rock area consists of *Pinus banksiana* and its associates. For the mountain trip two objectives were selected. Those preferring a lift were transported up Whiteface and left to walk down. Even then some ill-fitting shoes and weak knees raised havoc. The rugged personnel hiked the route over Algonquin. A good list of alpine species was recorded of which *Diapensia lapponica* and *Rhododendron lapponicum* were perhaps most attractive at the season.

The excursion was based at Champlain College and the tourist facilities of the Plattsburg, N. Y., area with day trips for the studies indicated above. Attendance 39.

BOOK REVIEWS

The Ferns and Fern Allies of Wisconsin. By R. M. Tryon, Jr. and others. Second edition. 1953. The University of Wisconsin Press.

It is an encouraging sign of interest in ferns to find a second edition called for this work which the late Mr. Weatherby termed "a happy result of co-operative effort" (Amer. Fern Jour. 31: 24. 1941). It will be recalled that Wisconsin was a pioneer in issuing what might be called a *fully* illustrated manual of ferns and fern allies of a state.

The chief changes in the second edition are, as stated in the preface, that "the names have been brought into line with those in the new GRAY'S MANUAL 8th ed." The authors retain the conservative attitude of the first edition, for instance, they have not seen fit to follow Fernald in transferring Ophioglossaceae to the group Eusporangiatae, but still include the family in "The True Ferns" (p. 5). As would be expected, the distribution maps have been brought up to date, indicating considerable recent field work.

Unfortunately the new edition has been printed on paper not entirely suited to the requirements of half-tone illustrations, so that these are on the whole less satisfactory than the ones in the first edition. A few typographic errors have been carried through both editions.—M. A. CHRYSLER, Rutgers University.

400 Plants of South Florida. By Julia F. Morton and R. Bruce Ledin. 134 pages. 28 figures. Text House, Coral Gables, Fla. 1952. $3.50.

This is a companion to *Fifty Tropical Fruits of Nassau* by Julia Morton and her husband (see Bull. Torrey Club 77: 232). It contains 412 paragraphs each headed by a specific name, a family name, and a common name or names if any are known (the authors are to be commended for resisting the tendency to manufacture "common" names for species not commonly named). The species are arranged in the alphabetical order of their scientific names; an index makes it possible to locate them also by their

common names. Each species is briefly described in non-technical words, with notes on origin and on economic uses and properties if any.

Some question arises of the usefulness of such a volume and of the readers for whom it is designed. According to the authors, the descriptions are meant "to aid the layman in recognition or confirmation." Because of the arrangement, the "layman" must usually first find his plant in the index. The disjunction of nearly related plants (as *Ipomoea* from *Quamoclit*, *Cordyline* from *Dracaena*, the genera of palms from each other) will make it more difficult for him to "confirm" his identification. However, with such reservations the little book may be recommended to visitors to subtropical Florida. It is attractively printed on good paper, and the illustrations are full-page drawings both accurate in detail and aesthetically charming; one can only wish that there had been several hundred of them instead of 28.—H. W. RICKETT.

Plants of Rocky Mountain National Park. By Ruth Ashton Nelson. Revised Edition. 1953. x + 201 pages. Illus. Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C. $1.00.

Some 750 species of vascular plants are included. This is over 50 more than in the original edition which has been out of print since 1945 but always in demand. Twenty pages, about half pictures, are used to introduce the reader to the book, the region, the life zones, and the general ecology. The general key is divided into woody plants, which are keyed to the species, and non-woody plants, which are keyed to the family or beyond. Large families have their own keys. Grasses, sedges, and rushes are separated and a list of species of each family from the Park is included. The Bibliography includes papers for their more technical study. Common names, following Standardized Plant Names, are given priority but scientific names are fully recorded, with the important alternatives.

It is scarcely possible to open the book without facing an illustration on one or both pages. Almost entirely half-tones, these have been admirably selected to serve their purpose and reproduced adequately. Line drawings (Plates X and XI) will help the novice with composites while others (Plates XII–XIV) are useful supplements to the glossary.

Although written with the "goal of offering a practical method of wildflower identification for the many nature lovers," this book will be a pleasant and useful companion for the strictly professional botanist visiting Rocky Mountain National Park and its vicinity.—JOHN A. SMALL.

BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 80, No. 6, pp. 518–529 NOVEMBER, 1953

INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITORS OF THE TAXONOMIC INDEX

TAXONOMY, PHYLOGENY AND FLORISTICS

ALGAE

(See also under Morphology: **Starr**)

Dawson, E. Yale. On the occurrence of *Gracilariopsis* in the Atlantic and Caribbean. Bull. Torrey Club **80**: 314–316. Jl 1953.

Kallio, Paavo. On the morphogenetics of the desmids. Bull. Torrey Club **80**: 247–263. Jl 1953.

Ortega R., Maria del Carmen. Estudios realizados en México sobre algas, liquenes, hepáticas y musgos. Anal. Inst. Biol. [Mexico] **23**: 39–52. 20 My 1953.

Silva, Herman. Fifteen new algae. Bull. Torrey Club **80**: 342–348. Jl 1953.

Taylor, Wm. Randolph, *et al.* The relation of *Dichotomosiphon pusillus* to the algal genus *Boodleopsis*. Pap. Mich. Acad. **38**[1]: 97–101, *pl. 1–3*. 1953.

BRYOPHYTES

(See also under Algae: **Ortega**; under Ecology: **Hamilton**)

Clark, Lois. *Frullania spruceana*. Bryologist **56**: 140–142. Je [Jl] 1953.

Clark, Lois & Frye, T. C. *Frullania peruviana*. Bryologist **56**: 134–137. Je [Jl] 1953.

Clark, Lois & Svihla, Ruth D. *Frullania osculatiana*. Bryologist **56**: 137–139. Je [Jl] 1953.

Cooke, Wm. Bridge. Mosses in a sewage treatment plant. Bryologist **56**: 143–145. Je [Jl] 1953.

Crum, Howard A. The propagula of *Pterygynandrum filiforme*. Bryologist **56**: 98–100. Je [Jl] 1953.

Herzog, Th. Beiträg zur Kenntnis der argentinischen Bryophytenflora. Repert. Sp. Nov. **55**: 1–27. 31 D 1952.

Lawton, Elva. *Lorentziella*, a moss genus new to North America. Bull. Torrey Club **80**: 279–288. Jl 1953.

Lawton Elva. Mosses of the Black Hills, South Dakota. Bryologist **56**: 116–121. Je [Jl] 1953.

Lepage, Ernest. Materials for a better knowledge of the hepatic flora of northern Quebec. Bryologist **56**: 101–115. Je [Jl] 1953.

Löve, Askell & Löve, Doris. Studies on *Bryoxiphium*. Bryologist **56**: 73–94. Je [Jl] 1953.

McCleary, James A. Additions to the Arizona moss flora. Bryologist **56**: 121–126. Je [Jl] 1953.

Meijer, Wim. The study of hepatics in the Malaysian tropics. Bryologist **56**: 95–98. Je [Jl] 1953.

Schuster, Rudolf M. Boreal Hepaticae, a manual of the liverworts of Minnesota and adjacent regions. Am. Midl. Nat. **49**: 257–684. Mr 1953.

Whitehouse, Eula. Collecting mosses in East-Central Africa. Field & Lab. **21**: 59–74. Ap 1953.

FUNGI
(See also under Algae: **Ortega**)

Alexopoulos, Const. J. & Beneke, E. S. New records of Myxomycetes from Michigan. Pap. Mich. Acad. **38**[1]: 3–7. 1953.

Baxter, Dow V. Some resupinate polypores from the region of the Great Lakes. XXIV. Pap. Mich. Acad. **38**[1]: 115–123. *pl. 1–5.* 1953.

Critopoulos, P. D. A contribution on the fungus flora of Greece. Bull. Torrey Club **80**: 325–341. Jl 1953.

Mains, Edwin B. *Stilbum tomentosum.* Pap. Mich. Acad. **38**[1]: 45–51. *pl. 1.* 1953.

Pady, S. M. & Kapica, L. Air-borne fungi in the Arctic and other parts of Canada. Canad. Jour. Bot. **31**: 309–323. My 1953.

Rudolph, Emanuel D. A contribution to the lichen flora of Arizona and New Mexico. Ann. Mo. Bot. Gard. **40**: 63–72. My 1953.

Smith, Alexander H. New and rare agarics from the Douglas Lake region and Tahquamenon Falls State Park, Michigan, and an account of the North American species of *Xeromphalina.* Pap. Mich. Acad. **38**[1]: 53–87. *pl. 1–8.* 1953.

Swank, George. The perfect stage of *Colletotrichum phomoides* on tomato. Phytopathology **43**: 285–287. My 1953.

Thirumalachar, M. J., Shaw, Charles Gardner & Narasimhan, M. J. The sporangial phase of the downy mildew on *Eleusine coracana* with a discussion of the identity of *Sclerospora macrospora* Sacc. Bull. Torrey Club **80**: 299–307. Jl 1953.

Zuckerman, Bert M. & Curl, E. A. Proof that the fungus pads on oak wilt-killed trees are a growth form of *Endoconidiophora Fagacearum.* Phytopathology **43**: 287, 288. My 1953.

SPERMATOPHYTES

Anderson, Edgar. An analysis of suspected hybrids, as illustrated by *Berberis* × *gladwynensis.* Ann. Mo. Bot. Gard. **40**: 73–78. My 1953.

Babcock, Ernest B. Supplementary notes on *Crepis* VI: Some species of Iran and Afghanistan. Univ. Calif. Publ. Bot. **26**: 213–222. 24 S 1952.

Bacigalupo, Nélida María. Las especies argentinas de los géneros *Psychotria, Palicourea* y *Rudgea* (Rubiaceae). Darwiniana **10**: 31–64. 31 D 1952.

Backeberg, Kurt. Neue Kakteen aus Brasilien—Cactáceas novas do Brasil. Arq. Jard. Rio de Janeiro **9**: 149–174. *pl. 1–8.* D 1949.

Baehni, Charles. Propositions pour améliorer le Code de la Nomenclature. Proposition n. 4 . . . Taxon **2**: 90–92. Je 1953.

Barneby, R. C. Pugillus *Astragalorum* XV: Four new species. Leafl. West. Bot. **7**: 31–38. 13 My 1953.

Barroso, Graziela Maciel. *Praxeliopsis*—um novo género de Compositae. Arq. Jard. Bot. Rio de Janeiro **9**: 175–178. *1 pl.* D 1949.

Boivin, Bernard. Additions to the flora of the Erie Archipelago (Ontario). Rhodora **55**: 224–226. Je 1953.

Brade, A. C. A gênero *Habenaria* (Orchidaceae) no Itatiaia. Rodriguésia **14**[26]: 7–21. *pl. 1–*[illegible]. D 1951.

Brade, A. C. Contribuição para o conhecimento da flora do Estado do Espírito Santo. II. Espécies novas das familias de Orchidaceae, Rubiaceae e Gentianaceae. Arq. Jard. Bot. Rio de Janeiro **9**: 9–35. *pl. 1–11.* D 1949.

Brass, L. J. Vegetation of Nyasaland. Report on the Vernay Nyasaland Expedition of 1946. Mem. N. Y. Bot. Gard. **8**: 161–190. 23 Je [7 Jl] 1953.

Bravo Hollis, Helia. Iconografía de las cactáceas mexicanas. (Segunda serie.) Cactaceas del suroeste de Tamaulipas. Anal. Inst. Biol. [Mexico] **23**: 501–557. 20 My 1953.

Brenan, J. P. M. *& collaborators.* Plants collected by the Vernay Nyasaland Expedition of 1946. Mem. N. Y. Bot. Gard. **8**: 191–236. 23 Je [7 Jl] 1953.

Brown, J. R. Notes on haworthias. Cactus & Succ. Jour. **25**: 31–33. Ap 1953.

Burkart, Arturo. El verdadero nombre botánico de "guayacán"; *Caesalpinia paraguariensis* (D. Parodi), nueva combinación. Darwiniana **10**: 25–30. 31 D 1952.

Burkart, Arturo. Una notable especie nueva de *Phaseolus* del noroeste Argentino (*Ph. geophilus*, n. sp.). Darwiniana **10**: 19–24. *pl. 1.* 31 D 1952.

Butters, Fred K. & Abbe, Ernst C. A floristic study of Cook County, northeastern Minnesota. Rhodora **55**: 21–55. *pl. 1190–1192.* F [3 Mr]; 63–101. 26 Mr; 116–154. 10 Ap; 161–201. 21 My 1953.

Cody, W. J. A plant collection from the west side of Boothia Isthmus, N. W. T., Canada. Canad. Field-Nat. **67**: 40–43. Ja–Mr 1953.

Corrêa Gomes, José. Contribuição ao conhecimento das Bignoniaceae brasileiras. II. *Manaosella* J. C. Gom. n. gn. (tribu Bignonieae). Arq. Jard. Bot. Rio de Janeiro **9**: 83–86. D 1949.

Cronquist, Arthur. Notes on specimens of American plants in European herbaria. Leafl. West. Bot. **7**: 17–31. 13 My 1953.

Daniel, H. Algunas observaciones sobre la flora colombiana. Revista Acad. Colomb. $9^{33, 34}$: 103–114. My 1953.

Dayton, William A. Seven small plant collections in Costa Rica and neighboring Panama. Phytologia **4**: 223–265. Je 1953.

Dugand, Armando. Dos palmas nuevas *Ceroxylon* de Colombia. Mutisia. **14**: 1–5. 15 My 1953.

Falção, J. I. Nova espécie de *Jacquemontia* [*monteroi*] Choisy. Rodriguésia 14^{26}: 41, 42. *1 pl.* D 1951.

Fosberg, F. R. Nomenclature of *Premna obtusifolia* R. Br. Taxon **2**: 88, 89. Je 1953.

Fosberg, F. R. Proposal to conserve the generic name *Citrullus* Schrader. Proposition n. 8 . . . Taxon **2**: 99–101. Je 1953.

Fosberg, F. R. Typification of *Euphorbia maculata* L. Rhodora **55**: 241–243. 17 Jl 1953.

Fox, W. Sherwood & Soper, James H. The distribution of some trees and shrubs of the Carolinian zone of southern Ontario, Part I. Trans. Roy. Canad. Inst. **29**: 65–84. 1953.

Gage, Marilyn Amy. The cytology, morphology and systematic relationships of *Delphinium* × *Belladonna* Hort. ex Bergm. Ann. Mo. Bot. Gard. **40**: 113–186. *pl. 7–15.* My 1953.

Glassman, S. F. New plant records from the eastern Caroline Islands, with a comparative study of the native plant names. Pacif. Sci. **7**: 291–311. Jl 1953.

Goodspeed, T. H. Species origins and relationships in the genus *Nicotiana.* Univ. Calif. Publ. Bot. **26**: 391–400. 16 Ja 1953.

Gould, Frank W. A cytotaxonomic study in the genus *Andropogon.* Am. Jour. Bot. **40**: 297–306. *1 pl.* 8 My 1953.

Guilherme de Almeida, Djalma. *Dalbergia frutescens* (Vell.) Britton. "Sebastião de Arrunda." Arq. Serv. Flor. [Rio de Janeiro] **5**: 15–34. *1 pl.* [1953].

Hanes, Clarence R. *Allium tricoccum* Ait., var. *Burdickii*, var. nov. Rhodora **55**: 243, 244. 17 Jl 1953.

Harkness, Bernard. Hortus durobrivensis. I. Phytologia **4**: 269–284. Je 1953.

Henry, Mary G. A new hybrid deciduous *Rhododendron* [× *gladwynense*]. Rhodora **55**: 205–208. *pl. 1193.* 17 Je 1953.

Howell, John Thomas. *Navarretia heterandra* in Oregon. Leafl. West. Bot. **7**: 40. 13 My 1953.

Howell, John Thomas. New records of western weeds. Leafl. West. Bot. **7**: 38–40. 13 My 1953.

Hutchinson, P. C. Studies of South American Cactaceae 2. *Echinocactus humilis* Philippi. A Chilean endemic with primarily juvenile stems. Cactus & Succ. Jour. **25**: 34–37. Ap 1953.

Irmscher, E. Systematische Studien über Begoniaceen des tropischen Südamerikas, besonders Brasiliens. Bot. Jahrb. **76**: 1–102. Ja 1953.

Johnston, Ivan M. Studies in the Boraginaceae, XXV. A revaluation of some genera of the Lithospermeae. Jour. Arnold Arb. **34**: 258–299. 15 Jl 1953.

Kimnach, Myron. The genus *Adromischus*. Cactus & Succ. Jour. **25**: 41–48. Ap 1953.

Kuhlmann, J. G. Uma nova espécie de *Landolphia* (Apocynaceae). Arq. Jard. Bot. Rio de Janeiro **9**: 95–99. D 1949.

Li, Hui-Lin. Floristic interchanges between Formosa and the Philippines. Pacif. Sci. **7**: 179–186. Ap 1953.

Lindsay, George. A new *Mammillaria* [*boolii*]. Cactus & Succ. Jour. **25**: 48, 49. Ap 1953.

Little, Elbert L. & Dorman, Keith W. Slash pine (*Pinus elliottii*), its nomenclature and varieties. Jour. Forest. **50**: 918–923. D 1952.

McAtee, W. L. Some undescribed forms of Nearctic *Viburnum*. Nat. Hist. Misc. **123**: 3 p. 20 My 1953.

Machado, Othon Xavier de Brito. Espécie nova de Acanthaceae: *Beloperone cecíliae* O. Machado, n. sp. Arq. Jard. Bot. Rio de Janeiro **9**: 109–111. D 1949.

Machado, Othon Xavier de Brito. Trés novas espécies de *Anacardium* do Brasil central. Arq. Jard. Bot. Rio de Janeiro **9**: 87–93. D 1949.

Machado, Othon Xavier de Brito. Uma nova *Nectandra* [*Labouriaviana*]. Arq. Jard. Bot. Rio de Janeiro **9**: 237–240. *2 pl.* D 1949.

Martínez, Maximino. Los encinos de México y Centroamérica. II. Anal. Inst. Biol. [Mexico] **23**: 53–83. 20 My 1953.

Matuda, Eizi. Las bromeliáceas de Chiapas. Anal. Inst. Biol. [Mexico] **23**: 85–153. 20 My 1953.

Millán, Roberto. Las hortalizas del género *Allium*. Darwiniana **10**: 90–111. *pl. 1–9.* 31 D 1952.

Moldenke, H. N. Additional notes on the Eriocaulaceae. X. Phytologia **4**: 295–304. Je 1953. XI. 311–341. Au 1953.

Moldenke, H. N. The known geographic distribution of the members of the Verbenaceae, Avicenniaceae, Stilbaceae, Symphoremaceae, and Eriocaulaceae. Supplement 10. Phytologia **4**: 266–268. Je 1953.

Moldenke, H N. Notes on new and noteworthy plants. XVI. Phytologia **4**: 285–295. Je 1953.

Monachino, J. V. A new species of *Strychnos* from the Rio Oiapoque. Phytologia 4: 209–212. Je 1953.

Pabst, G. F. J. Notícias orquidológicas—I. Rodriguésia 14[26]: 43–54. *pl. 1–12.* D 1951.

Palmer, Ernest J. A hybrid *Amorpha* and new forms and records from Missouri. Rhodora 55: 157–160. 21 My 1953.

Peattie, Donald Culross. A natural history of western trees. *i-xiv,* 1–751. *illus.* Houghton, Mifflin, Co. Boston. 1953.

Perry, Lily M. Plantae papuanae Archboldianae, XXI. The Papuasian species of *Macaranga.* Jour. Arnold Arb. 34: 191–257. 15 Jl 1953.

Ponce de León y Aymé, Antonio & Alvarez, Maria Teresa. Family names. Proposal n. 6 . . . Taxon 2: 96–98; Some nomina familiarum. Proposal n. 7 . . . 98, 99. Je 1953.

Reeder, John H. Affinities of the grass genus *Beckmannia* Host. Bull. Torrey Club 80: 187–196. My 1953.

Rizzini, Carlos Toledo. Acanthaceae Minàrum Generalium imprimis Mello-Barretianae. Arq. Jard. Bot. Rio de Janeiro 9: 193–207. D. 1949.

Rizzini, Carlos Toledo. *Bothriopodium,* genus novarum Bignoniacearum. Arq. Jard. Bot. Rio de Janeiro 9: 69–81. *pl. 1–6.* D 1949.

Rizzini, Carlos Toledo. Contribuição ao conhecimento da tribo Justicieae (Acanthaceae). Arq. Jard. Bot. Rio de Janeiro 9: 37–69. *pl. 1–3.* D 1949.

St. John, Harold & Mason, Leonard E. Vernacular names of the plants of Bikini, Marshall Islands. Pacific Plant Studies 12. Pacif. Sci. 7: 165–168. Ap 1953.

Schultes, Richard Evans. A new *Saurauia* [*comitis-rossei*] from Mexico. Bot. Mus. Leafl. 16: 112, 113. *pl. 19.* 6 Jl 1953.

Schultes, Richard Evans. Plantae austro-americanae VIII. De plantis principaliter vallis amazonicis novis vel criticis notae diversae. Bot. Mus. Leafl. 16: 57–95. *pl. 7–16.* 19 Je 1953.

Schultes, Richard Evans. Plantae colombianae XIV. *Rhytidantherae* montis Macarenae nova species. Bot. Mus. Leafl. 16: 106–111. *pl. 18.* 6 Jl 1953.

Schultes, Richard Evans & Cuatrecasas, José. Notes on the cultivated lulo. Bot. Mus. Leafl. 16: 97–105. *pl. 17.* 6 Jl 1953.

Schweinfurth, Charles. Studies on Peruvian *Pleurothallis.* Bot. Mus. Leafl. 16: 45–56. *pl. 5, 6.* 15 My 1953.

Sherff, Earl Edwards. I. Further notes on the genus *Tetraplasandra* A. Gray (fam. Araliaceae) in the Hawaiian Islands. Bot. Leafl. 8: 1–13. II. Notes on miscellaneous dicotyledonous plants. 13–26. 22 Je 1953.

Shinners, Lloyd H. *Filago arvensis* in Michigan: a second North American record. Rhodora 55: 228. 17 Je 1953.

Shinners, Lloyd H. Nomenclature of the varieties of *Monarda punctata* L. (Labiatae). Field & Lab. 21: 89–92. Ap 1953.

Shinners, Lloyd H. Notes: *Salvia farinacea* Benth. var. *latifolia* Shinners, var. nov. Field & Lab. 21: 92. *Valerianella florifera* Shinners, sp. nov. 93. *Pyrrhopappus georgianus* Shinners, sp. nov. 93, 94; *Sida ciliaris* L. var. *mexicana* (Moricand) Shinners, comb. nov. 94, Ap 1953.

Shinners, Lloyd H. Synopsis of the United States species of *Lythrum* (Lythraceae). Field & Lab. 21: 80–89. Ap 1953.

Smith, A. C. Studies of Pacific Island plants, XV. The genus *Elaeocarpus* in the New Hebrides, Fiji, Samoa, and Tonga. Contr. U. S. Nat. Herb. 30: 523–573. 1953.

Smith, L. B. Notes on Bromeliaceae. I. Phytologia 4: 213–219. *pl. 1, 2.* Je 1953. II. 355–368. *pl. 1–4.* Au 1953.

Stebbins, G. Ledyard, Jenkins, James A. & Walters, Marta S. Chromosomes and phylogeny in the Compositae, tribe Cichorieae. Univ. Calif. Publ. Bot. 26: 401–430. 14 My 1953.

Stebbins, G. Ledyard & Pun, Fung Ting. Artificial and natural hybrids in the Gramineae, tribe Hordeae. V. Diploid hybrids of *Agropyron.* Am. Jour. Bot. 40: 444–449. Je 1953.

Steyermark, Julian A. *Dodecatheon amethystinum* and forma *margaritacum* in the Missouri Ozarks. Rhodora 55: 226, 227. 17 Je 1953.

Thompson, Henry J. The biosystematics of *Dodecatheon.* Contr. Dudley Herb. 4: 73–154. 30 Je 1953.

Toledo, J. F. Estudos sôbre algumas palmeiras do Brasil, II—Notas sôbre o gênero *Acanthococos* Barb. Rodr. Arq. Bot. Est. S. Paulo II. 3: 3–9. *pl. 1, 2.* O 1952.

Toledo, J. F. Notulae de aliquot plantis brasilensibus novis vel minus cognitis. Arq. Bot. Est. S. Paulo II. 3: 27–43. *pl. 7–10.* O 1952.

Toledo, J. F. Notulae de *Cyclanthera* Schrad. Arq. Bot. Est. S. Paulo II. 3: 19–25. *pl. 5, 6.* O 1952.

Toledo, J. F. Species brasilienses *Agonandrae* Miers. Arq. Bot. Est. S. Paulo II. 3: 11–17. *pl. 3, 4.* O 1952.

Troncoso, Nélida Sara. Descripción de algunas especies nuevas o críticas de *Lippia* de la flora argentina. Darwiniana 10: 69–89. 31 D 1952.

Turner, B. L. & Beaman, J. H. Chromosome complements in *Desmanthus* (Leguminosae). Field & Lab. 21: 47–50. Ap 1953.

Van Royan, P. The Podostemaceae of the New World II. Acta Bot. Neerl. 2: 1–21. My 1953.

Waterfall, U. T. The identity of *Hedyotis rosea* Raf. Rhodora 55: 201–203. 21 My 1953.

Webber, John Milton. Yuccas of the southwest. U.S. Dep. Agr. Monogr. 17: 1–97. *pl. 1–72.* 1953.

ECOLOGY AND PLANT GEOGRAPHY

Beard, J. S. The savanna vegetation of northern tropical America. Ecol. Monogr. 23: 149–215. Ap 1953.

Cantlon, John E. Vegetation and micro-climates on north and south slopes of Cushetunk Mountain, New Jersey. Ecol. Monogr. 23: 241–270. Jl 1953.

Daubenmire, Rexford. Classification of the conifer forests of eastern Washington and northern Idaho. Northw. Sci. 27: 17–24. F 1953.

Elliott, Jack C. Composition of upland second growth hardwood stands in the tension zone of Michigan as affected by soils and man. Ecol. Monogr. 23: 271–288. Jl 1953.

Fireman, Milton & Hayward, H. E. Indicator significance of some shrubs in the Escalante Desert, Utah. Bot. Gaz. 114: 143–155. D 1952 [Mr 1953].

Frey, David G. Regional aspects of the Late-glacial and Post-glacial pollen succession of southeastern North Carolina. Ecol. Monogr. 23: 289–313. Jl 1953.

Guimarães, José Labão. Aspectos geo-botánicos, ecológicos do Km. 47 da rodovia Rio-São Paulo. Arq. Serv. Flor. [Rio de Janeiro] 5: 35–70. *pl. 1–20.* [1953].

Hamilton, Ernest S. Bryophyte life forms on slopes of contrasting exposures in central New Jersey. Bull. Torrey Club **80**: 264–272. Jl 1953.

Hatheway, William H. The land vegetation of Arno Atoll, Marshall Islands. Atoll Res. Bull. **16**: *i–ii*, 1–68. 30 Ap 1953.

Larsen, James A. A study of an invasion by red maple of an oak woods in southern Wisconsin. Am. Midl. Nat. **49**: 908–914. My 1953.

Neel, Joe Kendall. Certain limnological features of a polluted irrigation stream. Trans. Am. Micr. Soc. **72**: 119–135. Ap 1953.

Nielsen, Etlar L. Revegetation of alkali flood plains adjoining the North Platte River, Garden County, Nebraska. Am. Midl. Nat. **49**: 915–919. My 1953.

Niering, William A. The past and present vegetation of High Point State Park, New Jersey. Ecol. Monogr. **23**: 127–148. Ap 1953.

PALEOBOTANY

Arnold, Chester A. Origin and relationships of the cycads. Phytologia **3**: 51–65. Mr 1953.

Arnold, Chester A. Silicified plant remains from the Mesozoic and Tertiary of western North America. II. Some fossil woods from northern Alaska. Pap. Mich. Acad. **38**[1]: 9–20. *pl. 1–4.* 1953.

Huertas G., Gustavo & Van der Hammen, Thomas. Un posible banano (*Musa*) fósil del Cretáceo de Colombia. Revista Acad. Colomb. **9**[33, 34]: 115, 116. *2 pl.* My 1953.

MORPHOLOGY

(including anatomy and cytology in part)
(See also under Algae: **Kallio**)

Blum, John L. Vascular development in three common goldenrod galls. Pap. Mich. Acad. **38**[1]: 23–34. 1953.

Chou, Yü-Liang. Floral morphology of three species of *Gaultheria*. Bot. Gaz. **114**: 198–221. D 1952 [Mr 1953].

DeLamater, Edward D. Cytologic evidence for the occurrence of cellular and nuclear fusion in *Bacillus megaterium*. Bull. Torrey Club **80**: 289–298. Jl 1953.

Dermen, Haig. The pattern of tetraploidy in the flower and fruit of a cytochimeral apple. Jour. Hered. **44**: 31–39. Ja–F [My] 1953.

Fernández-Morán, H. & Dahl, A. Orville. Electron microscopy of ultrathin frozen sections of pollen grains. Science **116**: 465–467. 31 O 1952.

Filho, Armando de Mattos. As madeiras do gênero *Johannesia*. Arq. Jard. Bot. Rio de Janeiro **9**: 209–221. *pl. 1–3.* D 1949.

Milanez, Fernando Romano. Cristais de oxalato de cálcio om *Podocarpus Lambertii* Klotz. Arq. Jard. Bot. Rio de Janeiro **9**: 113–148. *pl. 1–6.* D. 1949.

Milanez, F. R. Nota sobre a anatomia da folha de *Coccoloba cereifera* Schwake. Rodriguésia **14**[26]: 23–39. D 1951.

Nagaraj, M. Floral morphology of *Populus deltoides* and *Populus tremuloides*. Bot. Gaz. **114**: 222–243. D 1952 [Mr 1953].

Nickerson, Norton H. Variation in cob morphology among certain archaeological and ethnological races of maize. Ann. Mo. Bot. Gard. **40**: 79–111. My 1953.

Occhioni, Paulo. Contribuição ao estudo anatômico de *Cinnamodendron Sampaioanum* Occh. Arq. Jard. Bot. Rio de Janeiro **9**: 101–108. D 1949.

Parker, Johnson. Desiccation in conifer leaves: anatomical changes and delimitation of the lethal level. Bot. Gaz. **114**: 189–198. D 1952 [Mr 1953].

Riley, Herbert Parkes & Irvin, Chester C. The duration of the stages of micros[p]orogenesis in *Gasteria*. Bull. Torrey Club **80**: 273–278. Jl 1953.

Shields, Lora Magura & Sattler, F. W. Xylem development in young internodes of the Kentucky wonder bean. Bot. Gaz. **114**: 243–248. D 1952 [Mr 1953].

Sohns, Ernest R. Floral morphology of *Ixophorus unisetus* (Presl) Schlecht. Jour. Wash. Acad. **43**: 179–182. Je 1953.

Starr, Richard C. On the morphology and reproduction of *Characium saccatum* Filarsky. Bull. Torrey Club. **80**: 308–313. Jl 1953.

Tepfer, Sanford S. Floral anatomy and ontogeny in *Aquilegia formosa* var. *truncata* and *Ranunculus repens*. Univ. Calif. Publ. Bot. **25**: 513–647. *pl. 47–61*. 16 Mr 1953.

GENETICS
(including cytogenetics)

(See also under Spermatophytes: **Anderson**; under Morphology: **Dermen**; under Plant Physiology: **Boothroyd**)

Caldecott, Richard S. The effects of X-radiation on genic material [in *Hordeum*]. Northw. Sci. **27**: 25–32. F 1953.

Dowrick, G. J. The chromosomes of *Chrysanthemum*, II: garden varieties. Heredity **7**: 59–72. *1 pl.* Ap [Je] 1953.

Ford, Lee. Cytogenetic study of a mutant maize F_1 plant from homozygous diploid × tester. Jour. Hered. **44**: 17–20. Ja–F [My] 1953.

Fyfe, Viviane C. Double reduction at the *Mid* locus in *Lythrum salicaria*. Heredity **7**: 285–292. Au 1953.

Haney, W. J., Gartner, J. B. & Wilson, G. B. The effect of light on the expression of heterosis. Jour. Hered. **44**: 10–12. Ja–F [My] 1953.

Johnson, B. Lennart. Evidence of irregularity in crossing over of the S locus in the eversporting type of *Matthiola incana* (L.) R. Br. Genetics **38**: 229–243. My [Jl] 1953.

Morrison, J. W. Chromosome behaviour in wheat monosomics. Heredity **7**: 203–217. *1 pl.* Au 1953.

Rhoades, M. M. & Dempsey, Ellen. Cytogenetic studies of deficient-duplicate chromosomes derived from inversion heterozygotes in maize. Am. Jour. Bot. **40**: 405–424. Je 1953.

Sachs, Leo. Chromosome behaviour in species hybrids with *Triticum timopheevi*. Heredity **7**: 49–58. *1 pl.* Ap [Je] 1953.

Schwartz, Drew. Evidence for sister-strand crossing over in maize. Genetics **38**: 251–260. My [Jl] 1953.

Skinner, J. C. Genetical variation in excised root cultures of a spinach relative (*Senecio vulgaris* L.). Jour. Hered. **43**: 299–302. N–D 1952 [Ap 1953].

Steiner, Erich. The results of hybridization between *Oenothera elata* and certain South American euoenotheras. Pap. Mich. Acad. **38**[1]: 89–96. 1953.

Steinitz-Sears, Lotti, M. & Sears, E. R. Chiasmata and crossing over in a dicentric chromosome in wheat. Genetics **38**: 244–250. My [Jl] 1953.

Storey, W. B. Genetics of the papaya. Jour. Hered. **44**: 70–78. Mr–Ap [Jl] 1953.

PLANT PHYSIOLOGY
(See also under Phytopathology: **Allen**)

Allen, Ethel K., Allen, O. N. & Newman, A. S. Pseudonodulation of leguminous plants induced by 2-bromo-3, 5-dichlorobenzoic acid. Am. Jour. Bot. **40**: 429–435. Je 1953.

Blouch, Roger, *et al.* Free amino acids in sugar-beet leaves altered by zinc dimethyldithiocarbamate. Bot. Gaz. **114**: 248–251. D 1952 [Mr 1953].

Boothroyd, E. R. The reaction of *Trillium* pollen-tube chromosomes to cold treatment during mitosis. Jour. Hered. **44**: 2–9. Ja–F [Mr] 1953.

Brancato, Frank P., & Golding, N. S. Gas requirements of molds: the importance of dissolved oxygen in the medium for germination and growth of several molds. Northw. Sci. **27**: 33–38. F 1953.

Eaton, Scott V. Effects of potassium deficiency on growth and metabolism of sunflower plants. Bot. Gaz. **114**: 165–180. D 1952 [Mr 1953].

Evans, Harold J. & Nason, Alvin. Pyridine nucleotide-nitrate reductase from extracts of higher plants. Plant Physiol. **28**: 233–254. Ap [Je] 1953.

Fraser, D. A. & Mawson, C. A. Movement of radioactive isotopes in yellow birch and white pine as detected with a portable scintillation counter. Canad. Jour. Bot. **31**: 324–333. My 1953.

Gardner, F. P. & Loomis, W. E. Floral induction and development in orchard grass. Plant Physiol. **28**: 201–216. Ap [Je] 1953.

Jacobs, Wm. P. & Bullwinkel, Bob. Compensatory growth in *Coleus* shoots. Am. Jour. Bot. **40**: 385–392. Je 1953.

Joham, Howard E. Accumulation and distribution of molybdenum in the cotton plant. Plant Physiol. **28**: 275–280. Ap [Je] 1953.

Jones, R. W. & Hamner, K. C. The intracellular distribution of ascorbic acid in turnip leaves. Plant Physiol. **28**: 314–316. Ap [Je] 1953.

Klein, W. H. & Leopold, A. C. The effects of maleic hydrazide on flower initiation. Plant Physiol. **28**: 293–298. Ap [Je] 1953.

Lind, E. F., Lane, H. C. & Gleason, L. S. Partial separation of the plastid pigments by paper chromatography. Plant Physiol. **28**: 325–328. Ap [Je] 1953.

Link, George K. K., *et al.* Role of nitrate-nitrogen nutrition in growth of tomato and crown-gall. Am. Jour. Bot. **40**: 435–444. Je 1953.

McCollum, J. P. Factors affecting cotyledonal cracking during the germination of beans (*Phaseolus vulgaris*). Plant Physiol. **28**: 267–274. Ap [Je] 1953.

MacDowall, F. D. H. Absence of acid phosphatase from chloroplasts of spinach and iris. Plant Physiol. **28**: 317–318. Ap [Je] 1953.

Machlis, Leonard. Growth and nutrition of water molds in the subgenus *Eual-lomyces*. II. Optimal composition of the minimal medium. Am. Jour. Bot. **40**: 450–460. III. Carbon sources. 460–464. Je 1953.

Machlis, Leonard & Ossia, Esther. Maturation of the meiosporangia of *Eual-lomyces*. II. Preliminary observations on the effect of auxins. Am. Jour. Bot. **40**: 465–468. Je 1953.

Marrè, E. & Murneek, A. E. Carbohydrate metabolism in the tomato fruit as affected by pollination, fertilization and application of growth regulators. Plant Physiol. **28**: 255–266. Ap [Je] 1953.

Muir, Robert M. & Hansch, Corwin. On the mechanism of action of growth regulators. Plant Physiol. **28**: 218–232. Ap [Je] 1953.

Newmeyer, Dorothy & Tatum, E. L. Gene expression in *Neurospora* mutants requiring nicotinic acid or tryptophan. Am. Jour. Bot. **40**: 393–400. Je 1953.

O'Kelley, Joseph C. The use of C^{14} in locating growth regions in the cell walls of elongating cotton fibers. Plant Physiol. **28**: 281–286. Ap [Je] 1953.

Phillips, Thomas G. & Averill, Warren. Phosphorylase and a branching enzyme in squash. Plant Physiol. **28**: 287–292. Ap [Je] 1953.

Rabideau, G. S. & Mericle, Leo W. The distribution of C^{14} in the root and shoot apices of young corn plants. Plant Physiol. **28**: 329–333. Ap [Je] 1953.

Schuler, John E., Diller, Violet M. & Kersten, Harold J. Preferential assimilation of ammonium ion by *Chlorella vulgaris*. Plant Physiol. **28**: 299–303. Ap [Je] 1953.

Scott, George T. & Hayward, Hugh R. Metabolic factors influencing the sodium and potassium distribution in *Ulva lactuca*. Jour. Gen. Physiol. **36**: 659–671. 20 My 1953.

Shields, Lora Mangum. Nitrogen sources of seed plants and environmental influences affecting the nitrogen supply. Bot. Rev. **19**: 321–376. Je 1953.

Siminovitch, D. & Briggs, D. R. Studies on the chemistry of the living bark of the black locust tree in relation to frost hardiness. IV. Effects of ringing on translocation, protein synthesis and the development of hardiness. Plant Physiol. **28**: 177–200. Ap [Je] 1953.

Siu, R. G. H. & Reese, E. T. Decomposition of cellulose by microorganisms. Bot. Rev. **19**: 377–416. Jl 1953.

Stevens, C. M. & Mylroie, A. Production and reversion of biochemical mutants of *Neurospora crassa* with mustard compounds. Am. Jour. Bot. **40**: 424–429. Je 1953.

Sussman, Alfred S. The effect of furfural upon the germination and respiration of ascospores of *Neurospora tetrasperma*. Am. Jour. Bot. **40**: 401–404. Je 1953.

Tukey, Loren D. Effects of night temperature on growth of the fruit of the sour cherry. Bot. Gaz. **114**: 155–164. D 1952 [Mr 1953].

Virtanen, Artturi I. The use of seeds with low content of trace elements in studies on essentiality of mirco-nutrients. Plant Physiol. **28**: 323, 324. Ap [Je] 1953.

Waggoner, Paul E. & Shaw, R. H. Stem and root temperatures. Phytopathology **43**: 317, 318. Je 1953.

Wedding, Randolph T. & Metcalf, Robert L. Translocation of radioactive octamethyl pyrophosphoramide in black valentine bean plants. Bot. Gaz. **114**: 180–189. D 1952. [Mr 1953].

Wood, R. D. & Straughan, Jeanette. Time-industry tolerance of *Lemanea fucina* to salinity. Am. Jour. Bot. **40**: 381–384. Je 1953.

PHYTOPATHOLOGY

(See also under Fungi: **Zuckerman & Curl**)

Allen, Paul J. Toxins and tissue respiration. Phytopathology **43**: 221–228. My 1953.

Barnett, H. L. & Staley, John M. Isolation of compatibility types of *Endoconidiophora fagacearum* from oak wilt trees naturally and artifically inoculated. Phytopathology **43**: 341–343. Je 1953.

Christie, J. R. Ectoparasitic nematodes of plants. Phytopathology **43**: 295–297. Je 1953.

Clayton, E. E. Control of tobacco diseases through resistance. Phytopathology **43**: 239–244. My 1953.

Conover, Robert A. & Walter, James M. The occurrence of a virulent race of *Phytophthora infestans* on late blight resistant tomato stocks. Phytopathology **43**: 344, 345. Je 1953.

Coons, George H. Disease resistance breeding of sugar beets—1918–1952. Phytopathology **43**: 297–303. Je 1953.

Dimond, A. E. & Waggoner, Paul E. Effect of lycomarasmin decomposition upon estimates of its production. Phytopathology **43**: 319–321. Je 1953.

Dimond, A. E. & Waggoner, Paul E. On the nature and role of vivotoxins in plant disease. Phytopathology **43**: 229–235. My 1953.

Doolittle, S. P. & Zaumeyer, W. J. A pepper ringspot caused by strains of cucumber mosaic virus from pepper and alfalfa. Phytopathology **43**: 333–337. Je 1953.

Gram, Ernst & Weber, Anna. Plant diseases in orchard, nursery and garden crops. Edited and adapted by R. W. G. Dennis. 1–618. *illus.* Philosophical Lib. Inc. New York. 1953.

Heim, Jean M. & Gries, George A. The culture of *Erysiphe cichoracearum* on sunflower tumor tissue. Phytopathology **43**: 343, 344. Je 1953.

Holton, C. S. Fusion between secondary sporidia in culture as an index of sex compatibility in *Tilletia* species. Phytopathology **43**: 322, 323. Je 1953.

Houston, Byron B. & Oswald, John W. The mosaic virus disease complex of ladino clover. Phytopathology **43**: 271–276. My 1953.

Luttrell, E. S. *Melanconium* leaf and stem fleck of grapes. Phytopathology **43**: 347, 348. Je 1953.

Mishra, J. N. Resistance of potato tubers to certain parasitic fungi. Phytopathology **43**: 338–340. Je 1953.

Munger, H. M. & Newhall, A. G. Breeding for disease resistance in celery and cucurbits. Phytopathology **43**: 254–259. My 1953.

Oswald, John W. & Houston, Byron B. Host range and epiphytology of the cereal yellow dwarf disease. Phytopathology **43**: 309–313. Je 1953.

Pound, Glenn S. & Fowler, Dorsey L. *Fusarium* wilt of radish in Wisconsin. Phytopathology **43**: 277–280. My 1953.

Silberschmidt, Karl. Studies on a mosaic of nasturtium occurring in Brazil. Phytopathology **43**: 304–308. Je 1953.

Spangelo, L. P. S. & Bolton, A. T. Suggested infection scales for roguing strawberry seedlings susceptible to *Mycosphaerella fragariae* and *Diplocarbon earliana*. Phytopathology **43**: 345–347. Je 1953.

Stevenson, F. J. & Akeley, Robert V. Control of potato diseases by disease resistance. Phytopathology **43**: 245–253. My 1953.

Tyner, L. E. The control of loose smut of barley and wheat by spergon and by soaking in water at room temperature. Phytopathology **43**: 313–316. Je 1953.

Willison, R. S. & Weintraub, M. Studies on stone-fruit viruses in cucurbit hosts—II. Some factors affecting the aging of inoculum in vitro. Phytopathology **43**: 324–328. III. The effect of cucurbit extracts on infectivity. 328–332. Je 1953.

GENERAL BOTANY
(including Biography)

Anderson, Edgar & Brown, W. L. The history of the common maize varieties of the United States corn belt. Agr. Hist. **26**: 2–8. Je 1952.

Andrews, Alfred C. The opium poppy as a food and spice in the classical period. Agr. Hist. **26**: 152–155. O 1952.

Buchanan, R. E. Transliteration of Greek words for use in nomenclature in botany. Proposal n. 5 . . . Taxon **2**: 93–96. Je 1953.

Burkart, Arturo. La obra de Holmberg como botánico. Darwiniana **10**: 1–18. 31 D 1952.

Ellis, Ralph V. & Dahl, A. Orville. Concerning reliability and unreliability of dried pollen from commercial sources. Jour. Allergy **18**: 55–59. Ja 1947.

Leal, Armando Santos. Joaquim Franco de Toledo [Ja 31, 1905–May 5, 1952]. Arq. Bot. Est. S. Paulo II. **3**: 45–49. *port.* O 1952.

Jaramillo Arango, Jaime. Don José Celestino Mutis y las expediciones botánicas españolas del siglo XVIII al Nuevo Mundo. Revista Acad. Colomb. $9^{33.\ 34}$: 14–31. *1 pl.* My 1953.

McVaugh, Rogers. The dates of publication of the volumes of the Annual Report and the Papers of the Michigan Academy. Pap. Mich. Acad. 38^{1}: 35–43. 1953.

Polunin, Nicholas. British floras ancient and modern. Rhodora **55**: 209–224. 17 Je 1953.

Pulle, A. A. D. F. Van Slooten. Taxon **2**: 85, 86. Je 1953.

Schulze, G. M. Beiträge zur deskriptiven Terminologie. Bot. Jahrb. **76**: 109–133. Ja 1953.

Svenson, Henry K. Linnaeus and the species problem. Taxon **2**: 55–58. My 1953.

Uribe Uribe, Lorenzo. La Expedición Botánica del Nuevo Reino de Granada; su obra y sus pintores. Revista Acad. Colomb. $9^{33.\ 34}$: 1–13. *1 pl.* My 1953.

INDEX TO VOLUME 80

Names of contributors are printed in CAPITALS. Names of new genera, species, varieties, forms and combinations are printed in **bold face**. Numbers in *italic* refer to pages on which the name is listed as a synonym. Numbers in **bold face** refer to pages on which the name is accompanied by a description or illustration.

Abies, 129; *balsamea*, 123, 129
Acaena pinnatifida, 473
Acaulon, 279; *megalosporum*, 279, 281, 283; *rubrum*, 281; *rufescens*, 281; *Runyoni*, 279, 281
Acer, 128; *rubrum*, 266, 270; *saccharum*, 267, 270; *spicatum*, 126, 127
Acetobacter, 202; *suboxydans*, 52
Aegilops caudata, 334; *crassa*, 331, 334; *cylindrica*, 331
Agrimonia striata, 473
Agrobacterium tumefaciens, 217, 218, 219, 223
AHMAD, M.: Biochemical investigations in *Saccharomyces*, 197
Albugo, 304, 305; *evolvuli*, 304; *tragopogonis*, 304
Alchemilla fissa, 473
Alcimandra, 349
Alfaroa costaricensis, 366
Algae, fifteen new, 342
Alisma plantago, 498; *plantago-aquatica*, 498
Allium, 273, 501, 502; *cepa*, 134, 501, 502, 504, 505; *paniculatum*, 329
Alnus, 128; *rugosa*, 126, 127; *serrulata*, 367
Alopecurus, 193, 194, 303
Alternaria, 338; *cichorii*, 337; *raphani*, 337; *tenuis*, 338; *tenuissima*, 338
Althea pallida, 332
Amanita, 60
Amaranthus verschaffeltii, 173
Amblystegium fluitans, 99; *varium*, 267, 268, 269
Amentiferae and Ranales, Secondary xylem elements of, 365
Amygdalus communis, 475
Andromeda glaucophylla, 515
Andropogon, 155
Anemone, 333
Eneuploidy in *Phalaris* spp., 16
Anthericum ramosum, 169
Anthoceros, 67, 68, 71, 73, 74; *dissectus*, 65, 66, 74; *endiviaefolius*, 67; *fuciformis*, 68, 70, 72, 73, 74; *giganteus*, 69; *husnoti*, 72; *venosus-ravenelii*, 73
Anthocerotales, Studies on, 65
Antirrhinum majus, 329
Aorate costaricana, 160
Aphanomyces, 385, 386; *byzantina*, 385; *camptostylus*, 385, 396; *cladogamus*, 385, 396; *cochlioides*, 385; *euteiches*, 385; *levis*, 385
Apinagia dissecta, 67
Apium graveolens, 336
Aplectrum hyemale, 515
Aralia nudicaulis, 126, 128
Argythamnia, 420; **Arlynniana, 420**, 421; **Dressleriana, 422**, 423; **Gentryi, 421**, 422; *lanceolata*, 421; *manzanilloana*, 422; *serrata*, 422, 423
Aricularia, 60
Armeria canescens, 327
Aromadendron, 349
Ascobolus furfuraceus, 2; *magnificus*, 1, 2, 3, 4, 7, 8, 9, 10, 11, 12; *stercorarius*, 2
Ascophanus carneus, 2
Ascus development in *Ascobolus magnificus*, A cytological study of, 1
Aspergillus ochraceus, 336
Asphodelus microcarpus, 329, 330
Aspidium simulatum, 99
Asplenium, 76, 77, 81, 82, 85, 87, 89, 91, 92, 93; *Adiantum-nigrum*, 89; *auritum*, 76; *ebenoides*, 91; *falcatum*, 76; *formosum*, 87; *harpeodes*, 87; *heterochroum*, 85, 87; *leucostegioides*, 76, 77, 78, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91, 92, 93, 94; *lobulatum*, 76; *Macraei*, 76; *marinum*, 89; *monanthes*, 77, 80, 81, 82, 83, 84, 85, 87, 88, 90, 91; *normale*, 77, 80, 81, 82, 83, 84, 85, 87, 88, 90, 91; *platyneuron*, 81, 83, 84, 85, 87; *radicans*, 76; *resiliens*, 81, 82, 83, 85; *Ruta-muraria*, 89, 92; *septentrionale*, 89, 92; *Trichomanes*, 80, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91, 93; *Trudelli*, 91; *viride*, 89
Asplenium prototype of the genus *Diellia*, 76
Aster subulatus, 100
Athyrium thelypterioides, 515
Atrichum undulatum, 267, 268, 269
Auriscalpium vulgare, 21, 23, 24
Avena barbata, 330, 331; *byzantina*, 335; *sativa*, 335, 385
Baccharis halimifolia, 100
Bacillus megaterium, 289, 290, 292, 293, 294, 295, 296, 297

BAKER, H. G.: Aggregations formed by motile protozoa, 419
Balanops australiana, 366, 379
BALL, ERNEST: Culture of plant tissues, 409
Basidiophora, 299
Basidium development in *Coleosporium sidae*, 205
Beckmannia, 187, 191, 192, 193, 194, 195; *eruciformis*, 187, 192, 194; *syzigachne*, 188, 191, 194
Beckmannia Host, Affinities of the grass genus, 187
Berberis cretica, 331; *fendleri*, 331
BERGER, C. A. & E. R. WITKUS: A Cytological study of the development of *Galtonia candicans* Decne., 501
Berteroa incana, 172, 173
Beta vulgaris, 168, 385
Betula lutea, 366, 378; *nigra*, 266, 267, 270; *papyrifera*, 123
BLUM, JOHN L.: The racemose Vaucheriae with inclined or pendent oogonia, 478
BOIVIN, BERNARD: Thalictrum cardenasianum, Sp. N., 136
BOLD, HAROLD C. & RICHARD C. STARR: A new member of the Phacotaceae, 178
Boletus, 60; *piperatus*, 60
Botrychium dissectum, 515; forma *obliquum*, 515; *matricariaefolium*, 515
Bovista, 22
Brachiaria platyphylla, 189, 194
Brachiomonas, 182
Branchipus, 312
Brassica oleracea var. *capitata*, 337
Bremia lactucae, 326
Bromus inermis, 131; *sterilis*, 330
Bryophyllum, 217
Bryophyte life forms, 264
Buchloë dactyloides, 190, 195
BUELL, MURRAY, F. & WILLIAM A. NIERING: Vegetation of a raised bog near Itasca Park, Minnesota, 123
Bupleurum falcatum, 170, 172; *rotundifolium*, 350; *semidiaphanum*, 330
Buxus sempervirens, 170, 172, 173, 174
Calamagrostis canadensis, 126
Calamintha incana, 333
Caliergonella schreberi, 128
Calocera cornea, 37, 39; *viscosa*, 37, 38, 39
Calopogon pulchellus, 515
Caltha palustris, 126, 128
Camptogastra coetera, 136
Camptosorus, 88, 89, 92
Campylium hispidulum, 267, 268, 269
Capsella bursa-pastoris, 325, 326
Capsicum annuum, 337, 338
Carduus pycnocephalus, 330
Carex, 126
Carpinus, 378; *caroliniana*, 266, 267, 367, 379
Carteria, 182
Carya cordiformis, 266, 267, 270; *glabra*, 266, 270, 367
Castanea, 317; *dentata*, 143, 366, 378
Castanopsis, 317, 318; *acuminatissimus*, 318; *borneensis*, 320; *brevistella*, 317; *carlesii*, 317, 318, 319; *carlesii* var. *carlesii*, 318; *carlesii* var. *sessilis*, 318; *chrysophylla*, 366; *kawakami*, 319; *longicaudata*, 318, 319; *stipitata*, 318, 319; *uraiana*, 322
Ceanothus ovatus, 516
Cellular fusion in *Bacillus megaterium*, 289
Celtis occidentalis, 267
Cenchrus tribuloides, 100
Cenococcum, 60; *graniforme*, 61
Centaurea scabiosa, 169
Ceratostomella, 513
Cercidiphyllum japonicum, 367, 378
Cercocarpus betulaefolius, 473; *parvifolius*, 473; apii var.
Cercospora apii var. *petroselini*, 340; *petroselini*, 340
Cerotelium fici, 327
Ceterach, 81, 89, 92; *officinarum*, 92
Chamaebatia foliolosa, 473
Chamaebryum, 287
Characium, 308, 312; *angustum*, 308, 309, 312; *limneticum*, 308; *saccatum*, 308, 309, 312, 313; *Sieboldii*, 308, 309, 312
Chlamydomonas, 182
Chlorella, 509
Chloris verticillata, 190, 195
Chlorococcum infusionum, 312
CHRYSLER, M. A. (Reviews) 140, 516
CHUTE, HETTIE M. (Review) 98
Cichorium intybus, 337
Cirsium arvense, 334; *canum*, 169, 171; *lanceolatum*, 330; *vulgare*, 330
Citrus, 455; *aurantium*, 337
Cladonia, 268
Cladosporium herbarum, 338
CLARK, HAROLD E. (Review) 352
Clathrococcum, 160, 161
Clavaria, 21, 60; *glossoides*, 36
Clematis, 376, 379; *dioscoreifolia*, 367, 376; *dioscoreifolia* var. *robusta*, 95; *virginiana*, 95, 376
Clinopodium vulgare, 333
Clitocybe, 60
Clitopilus, 60
Closterium, 260, 261

Clostridium septicum, 202
Coleosporium, 205, 206, 207, 212, 213, 214; *crowellii*, 213; *helianthi*, 205, 210; *inulae*, 334; *pinicola*, 213; *senecionis*, 205; *sidae*, 205, 213, 215; *sonchi-arvensis*, 205; *vernoniae*, 205, 206, 207, 210
Collybia, 60
Comptonia peregrina, 367
Conservation of life in desiccated tissues, 166
Coprinus, 60
Cordyline, 517
Cornus canadensis, 126, 128; *florida*, 266; *stolonifera*, 126, 127
Cortinellus, 60
Corylus Avellana, 367
Corynebacterium diphtheriae, 51
Cowania mexicana, 473
Cosmarium, 260
Crataegus heldreichii, 328
CRITOPOULOS, P. D.: Fungus flora of Greece, 325
Crown gall disease, a heat chamber for the study of, 217
CUATRECASAS, JOSE: New taxa in the genus *Diplostephium*, 401
Culture of plant tissues, 409
Cyclobalanopsis, 317, 323; *glauca*, 323, 324; *hypophyaea*, 321; *kanehirai*, 324; *longinux*, 323; *pachyloma*, 324; *pseudomyrsinaefolia*, 324; *sasakii*, 323; *stenophylla* var. *latifolia*, 324; *stenophylloides*, 324; *tomentosicupula*, 324
Cydonia oblonga, 328; *japonica*, 473
Cynodon dactylon, 335
Cynosurus echinatus, 326
Cypripedium, 515; *acaule*, 515; *arietinum*, 515; *Calceolus*, 515; *candidum*, 515; *reginae*, 515; *spectabile*, 515
Cystopus candidus var. *globosus*, 325; *portulacae*, 325
Cytological study of aseus development in *Ascobolus magnificus*, 1
Dachryomyces, 60
Dacrymyces, 35; *minor*, 34, 35
Dacryomitra, 36; *glossoides*, 34, 36, 37; *nuda*, 36
Dactylis glomerata, 113, 120, 189, 195
Dactyloctenium aegypticum, 190, 195
Daedalea, 60
Dalibarda repens, 473
DAMON, SAMUEL: Notes on *Spegazzinia* Sacc. and *Isthmospora* Stevens, 155
Daucus carota var. *sativa*, 326
DAWSON, E. YALE: Occurrence of *Gracilariopsis*, 314
Degeneria, 472; *vitensis*, 366, 379
Degeneriaceae, 476
DELAMATER, EDWARD D.: Cellular fusion in *Bacillus megaterium*, 289
Dendroceros, 69, 73, 74; *cichoraceus*, 68, 69, 70, 72, 74; *crispus*, 69, 72, 74; *endiviaefolius*, 66, 67, 68, 74; *giganteus*, 69, 74
Deschampsia flexuosa, 189, 195
Desmids, 247
Diapensia lapponica, 516
Dicranella heteromella,, 267, 268, 269
Dicranum scoparium, 267, 268, 269, 271
Dictyoarthrinium quadratum, 164; *sacchari*, 164
Diellia, 76, 77, 80, 81, 82, 84, 85, 87, 88, 89, 90, 91, 92, 93; *Alexandri*, 85, 87, 88; *erecta*, 76, 80, 81, 82, 83, 88; *falcata*, 80, 81, 82, 84, 85, 87, 88, 89; *laciniata*, 89, 92; *Mannii*, 80, 82, 85, 92; *unisora*, 80, 81, 82, 83, 92
Diplostephium **crassifolium, 401,** 402; *denticulatum*, 403; *ellipticum*, 404; **espinosae, 402; fosbergii, 403;** *glutinosom* forma **microphyllum, 408; goodspeedii, 404; grantii, 403,** 404; **gynoxyoides, 405;** *haenkei*, 405; *hartwegii*, 402; *hippophae*, 407; **lacunosum, 406;** *lavandulifolium*, 402; **peruvianum, 406,** 407; *pleistogynum*, 408; *pleistogynum* var. **orientale, 408; ramiglabrum, 407;** *vermiculatum*, 407
Dracaena, 517
DRECHSLER, CHARLES: New species of *Plectospira*, 385
Drimys Winteri, 366
Drosera intermedia, 515; *longifolia*, 515; *rotundifolia*, 515
Droseraceae, 515
Dryas, 471; *octopetala*, 471, 473
Duchesnea indica, 473
Dysmorphococcus, 178, 184, 185; *coccifer*, 184; **globosus, 178,** 179, 182, 184, 185; *variabilis*, 179, 184, 185
Echinochloa crusgalli, 189, 195
Ectosperma hamata, 486, 490; *racemosa*, 483, 485; *terrestris*, 486, 487, 488, 489
Eleusine coracana, 192, 299, 300, 305; *indica*, 190, 192, 195
Elmerrilia, 349
Elytrophorus spicatus, 306
Engelhardtia pterocarpa, 366
Endomyces, 289
Epicoccum, 161; *neglectum*, 162; *nigrum*, 161
Epilobium roseum, 333
Eragrostis, 299
Erpodium, 279

Eryngium campestra, 330
Erysiphe cichoracearum, 326; *graminis*, 326; *graminis* var. *hordei*, 326; *pisi*, 326; *taurica*, 326
Euastrum, 248, 259, 260; *bidentatum*, 260; *crassicolla*, 346; *denticulatum*, 259; *pectinatum*, 260; *pinque*, 260; **tribulbosum**, 343, 345, 346
Euglena gracilis var. *bacillaris*, 419
Euglenopsis **minor**, **346**, 347
Eupatorium coelestinum, 99
Euphorbia cyparissias, 95, 335; *helioscopia*, 335; *heterophylla*, 499
Eurhynchium serrulatum, 267, 268, 269, 270
Evonymus americanus, 143; *japonica*, 336
Exidia alba, 35, 37
Exochorda, 471; *Alberti*, 473; *grandiflora*, 471, 473
Fagaceae of Formosa, 317
Fagus, 317, 373; *grandifolium*, 266, 267, 366, 373
Fallugia paradoxa, 473
Femsjonia pezizaeformis, 36, 37
Festuca, 333; *arundinaceae*, 19; *elatior*, 189, 195, 385; *glauca*, 169, 170; *rubra*, 385
Ficus carica, 327
Field trip reports, 98, 142, 425, 515
Flammula, 60
Flora of South-Central Texas, 350
Fomes, 43, 44, 60, 62; *fraxinophilus*, 44, 46, 47, 52, 53, 54, 61, 62; *pini*, 46, 47, 52, 53, 55; *roseus*, 46, 47, 53, 55
Fragaria, 463, 471; *vesca*, 473
Fraxinus americana, 266, 267, 270
Freesia, 134
Fungus flora of Greece, 325
Furcilia **rotunda**, **342**, 344
Fusarium, 509; *aquaeductum*, 509; *episphaeria*, 509, 513; *oxysporum*, 340; *solani*, 340
Galium triflorum, 126
Galloway a pinicola, 205, 206
Galtonia, 501, 503; *candicans*, 501, 502, 503, 504, 505
Galtonia candicans, Cytological study of the development of, 501
Ganoderma lucidum, 22
Gasteria, 273, 274, 275, 278; *margaritifera*, 274, 276, 277; *nitida*, 274, 275; *Zeyheri*, 274, 276, 277
Gelasinospora tetrasperma, 212
Gentiana Saponaria, 143
Geotrichum candidum, 510
Geum, 463, 471; *rivale*, 471, 473
Gigaspermum, 279, 286, 287; *repens*, 286
Gillenia, 471; *stipulacea*, 473; *trifoliata*, 471, 473
Glaucoma pyriformis, 419
Glocotulasnella, 33, 40, 41; **aggregata**, 39, **40**, 41; **caroliniana**, 39, **41**; *pinicola*, 40; *rogersii*, 41
Glomerella, 14, 207
Glycine max, 336
Goodyeara pubescens, 515
Gracilariopsis, 314, 315, 316
Gracilariopsis, Occurrence in Atlantic and Caribbean, 314
Gryllus, 155
Gucpiniopsis, 38; *merulinus*, 38; *torta*, 37, 38, 39
GUNCKEL, JAMES E. (Review) 351
GUNCKEL, JAMES E., IELENE B. MORROW, ARNOLD H. SPARROW & ERIC CHRISTENSEN: Variations in the floral morphology of normal and irradiated plants of *Tradescantia paludosa*, 445
Gymnosporangium clavariforme, 328; *juniperium*, 328; *sabinae*, 328
Gynoxys, 406
Habenaria blephariglottis, 515; *cristata*, 99; *dilatata*, 515; *hyperborea*, 515; *integra*, 99; *lacera*, 515; *nivea*, 99; *psycodes*, 515
Haematococcus, 182
Hamamelis virginiana, 267
HAMILTON, ERNEST S.: Bryophyte life forms, 264
HANSON, A. A. & HELEN D. HILL: Aneuploidy in *Phalaris* spp.; Meiotic behavior of hexaploid orchard grass (*Dactylis glomerata*), 113
Haynaldia villosa, 333
Hedera, 469; *helix*, 174
Helianthus annuus, 331, 455
Heliotropium europaeum, 327
Hepatica, 333
HESSELTINE, C. W.: Study of trickling filter fungi, 507
Heteronema bifurcata, 344, 347; **longiovata**, 344, **347**; **nebuloglabra**, 344, **347**, 348; *nebulosa*, 347
Hexaploid orchard grass, 113
Hibiscus esculentus, 336
Hieracium Hoppeanum, 134
Himantandra, 373, 375, 376; *Belgraveana*, 366
Hordeum, 332; *bulbosum*, 331; *murinum*, 332
Hormidium rivulare, 348
Houstonia longifolia, 516
Humaria rutilans, 1
Hydnum, 60

Hydrothyria venosa, 99
Hymenomycetes, Essential metabolites for, 43
Hyphal systems of *Auriscalpium vulgare*, 21
Hypholoma, 60
Hypnum cristacastrensis, 128; *patientiae*, 267, 268, 269
Hypomyces, 5
ILJIN, W. S.: Conservation of life in desiccated tissues, 166
Illicium, 349, 350; *anisatum*, 349, 350, 367; *floridanum*, 349, 350
Impatiens capensis, 126
Imperata cylindrica, 335
Index to American botanical literature, 102, 145, 234, 355, 432, 518
INGRAM, JOHN: New species and new combinations in the genus *Argythamnia*, 420
Inula attica, 334
Ipomoea, 517; *pandurata*, 100
Isoetes engelmanni, 100
Isthmospora, 155, 156, 160, 162; *glabra*, 160; *spinosa*, 155, 159, 160, 163; **trichohila**, 159, 160, **163**
Iva frutescens, 100
JOHNSON, M. A.: Magnoliaceae, relationship as determined by precipitin reaction, 349; (Review) 352
Juglans nigra, 366, 378
Juniperus oxycedrus, 328
Kadsura, 374, 375; *coccinea*, 366
KAEISER, MARGARET: Microstructure of the wood of the three species of *Taxodium*, 415
Kageneckia, 471
KALLIO, PAAVO: On the morphogenetics of the desmids, 247
Kalmia polifolia, 515
Kerria japonica, 473
KMERIA, 349
KNOBLOCH, WILLIAM IRVING: Tetraploid smooth bromegrass, 131
Koeleria cristata, 331; *phleoides*, 330, 331
KORF, RICHARD P. (Review) 142
Kuromatea glabra, 320
Lacis, 67
Lactarius, 60; *deliciosus*, 61
Lactobacillus casei, 61; *helveticus*, 61
Lactoris fernandeziana, 366, 379
Lactuca sativa, 326
Lagurus ovatus, 332
Larix laricina, 125
Lathyrus, 385; *pratensis*, 327
Lavatera arborea, 332
LAWTON, ELVA: *Lorentziella*, a moss genus new to North America, 279
LEHR, J. HARRY: Millspaugh's Footsteps retraced after sixty-nine years, 515
Leitneria floridana, 366
Lentinus, 60
Lenzites, 21, 60
Lepiota, 60
Leptangium, 279; *imbricatum*, 279, 280, 283, 285, 287
Leptochloa scabra, 190, 195
Leucobryum glaucum, 167, 268, 269
LEVINE, MICHAEL: A heat chamber for the study of the crown gall disease under controlled temperature and humidity, 217
LI, HUI-LIN: Taxonomic notes on the Fagaceae of Formosa, 317
Limlia, 323; *uraiana*, 322
Limonium carolinianum, 100; *vulgare*, 327
Linaria, 499
Lindera benzoin, 267, 270
Lindleye, 471; *mespiloides*, 471, 473
Linum usitatissimum, 386
Liriodendron, 349, 350; *tulipifera*, 266, 349, 366, 378
Lithocarpus, 317, 318, 320, 321; *amygdalifolius*, 320; *cornea*, 322; *densiflora*, 366; *dodonaeifolia*, 320; *glabra*, 320, 321; *hypophyaea*, 321; *kodaihoensis*, 321; *konishii*, 321, 322; *longicaudata*, 318, 319; *randaiensis*, 322; *stipitata*, 318, 319; *suishaensis*, 322; *taitoensis*, 320; *uraiana*, 322
Lolium perenne, 19; *rigidum* var. *compressum*, 331, 332; *temulentum*, 332; *temulentum* var. *arvense*, 332
Lorentziella, 279, 286, 287; *Giberti*, 280, 281, 283, 285; *glauca*, 279, 280, 281, 285; *globiceps*, 279, 280, 281, 285; *imbricata*, 280, 281, 285; *paraguensis*, 279, 280, 281, 283, 285; *Uruguensis*, 279
Lorentziella, a moss genus new to North America, 279
Lupinus hirsutus, 327; *perennis*, 99
Lycopersicon esculentum, 27, 335, 336, 338, 340, 385
Macrophomina phaseoli, 335
Macrosporium parasiticum, 338; *sarcinula*, 338
Magnolia, 349, 350; *grandiflora*, 366, 378, 379; *kobus*, 349, 350; *obovata*, 349; *portoricensis*, 349; *tripetala*, 349, 350; *virginiana*, 349
Magnoliaceae, Relationship as determined by precipitin reaction, 349
Mahonia, 331
Malaxis brachypoda, 515

Malus, 471; *pumila*, 328; *spectabilis*, 471, 473
Malva, 332; *sylvestris*, 332
Manglietia, 349; *hainanensis*, 366
Marasmius, 60
Matricaria chamomilla, 326
MATZKE, EDWIN B. (Review) 97
Medicago sativa, 328
Megaceros, 67, 69, 73, 74; *giganteus*, 69
Meiotic behavior of hexaploid orchard grass (*Dactylis glomerata*), 113
Melampsora euphorbiae, 334; *helioscopiae*, 335; *magnusiana*, 335
Melanomma, 161; *pulvis-pyrius*, 161
Melanotaenium, 498, 499; *endogenum*, 499; **euphorbiae, 499**; *hypogaeum*, 499
Meliola, 159, 160, 163
Meliosma from the Colombian Andes, a new, 500
Meliosma **bogotana, 500**
Menispermum canadense, 472
Mentha longifolia, 333
Menyanthes trifoliata, 515
Merulius, 21, 60
Michelia, 349, 350; *champaca*, 349; *fuscata*, 366
Micrasterias, 247, 248, 249, 251, 253, 254, 256, 258, 259, 260, 261; *angulosa*, 249, 251; *crux melitensis*, 249; *denticulata*, 249, 251, 253; *fimbriata* var. *caudata*, 247; *Mahabuleshwarensis* var. *Wallichii*, 259; *Murrayi* var. *triquetra*, 259; *papillifera*, 251, 253; *pinnatifida* var. *trigona*, 259; *radiata*, 249; *rotata*, 247, 249, 251, 253; *rotata* var. *evoluta*, 251; *Thomasina*, 249, 250, 253, 254, 255, 256, 257, 258, 268; *Thomasiana* var. *notata*, 247, 249, 250, 251, 253, 256, 257; *truncata*, 249, 259
Microsporogenesis, Duration of in *Gasteria*, 273
Microstylis monophyllos, 515
Millspaugh's footsteps retraced after sixty-nine years, 515
Mitella nuda, 126, 128
Mnium, 126, 128; *affine*, 267, 268, 269; *cuspidatum*, 126, 267, 268, 269; *medium*, 126; *undulatum*, 168
MONACHINO, JOSEPH: *Strophanthus glabriflorus*, 412
Morphogenetics of the Desmids, 247
Morphology and reproduction of *Characium saccatum*, 308
Mycena, 60
Myrica pensylvanica, 367
Nemopanthus mucronata, 515
Neurospora, 98, 202; *crassa*, 8, 13, 14, 207; *tetrasperma*, 13
Nicotiana glutinosa, 217; *Tabacum*, 27, 217, 326
Nostoc, 67
Nothofagus, 373; *antarctica*, 366, 373
Notothylas, 71, 73
Nozemia, 303; *macrospora*, 305
Nuttallia cerasiformis, 473
Odontia, 35
Oedipodiella, 287
Oedogonium inconspicuum, 343; **Kurzii var ovatum, 342; sphaerico-inconspicuum, 343, 344**
Oidium abelmoschi, 336; *evonymi-japonicae*, 336
OLIVE, LINDSAY S.: New or noteworthy species of Tremellales from the southern Appalachians II, 33
Oocystis **brevispina, 342, 344**
Oospora lactis, 509, 510, 513
Ophioglossaceae, 5, 16
Ophiostomataceae, 513
Orchidaceae, 515
Orchis spectabilis, 515
Ostrya virginiana, 267, 367, 378
Pachylarnax, 349
Paeonia suffruticosa, 366
PALMQUIST, EDWARD M.: (Review), 232
Panicum, 191; *clandestinum*, 189, 195; *syzigachne*, 187; *verrucosum*, 143
Panus, 60
Papularia arundinis, 340
Papulospora magnifica, 2
Pasania, 317, 320, 321; *amygdalifolia*, 320; *cuspidata*, 319; *dudonaeifolia*, 320; *formosana*, 320; *glabra*, 320; *hypophyaea*, 321; *kodaihoensis*, 321, 322; *konishii*, 321, 322; *longicaudata*, 318, 319; *randaiensis*, 322; *rhombocarpa*, 322; *sieboldiana*, 321; *thalassica*, 320; *uraiana*, 322
Patella malaloma, 1, 14
PATRICK, RUTH (Review), 428
Penicillium chrysogenum, 337; *citrinum*, 337; *digitatum*, 337; *italicum*, 337; *meleagrinum*, 337; *stoloniferum*, 337; *urticae*, 337
Pennisetum typhoideum, 299
Peranema trichophora, 347, 348
Peronospora leptosperma, 326; *parasitica*, 326; *sisymbrii-officinalis*, 326
PETERSEN, ALICE E.: A comparison of the secondary xylem elements of certain species of the Amentiferae and Ranales, 365

Petroselinum crispum, 340; *sativum*, 340
Phacotaceae, A new member of the, 178
Phaeoceros, 67, 17
Phalaris, 16, 20, 187; *arundinaceae*, 16, 17, 18, 19, 20, 189, 195; *californica*, 16, 17, 19; *canariensis*, 16, 17, 18, 19; *coerulescens*, 16, 17, 19; *eruciformis*, 187; *minor*, 16, 17, 18, 19, 20; *paradoxa*, 16, 17, 19; *tuberosa*, 16, 17, 19
Phascum, 279
Phaseolus vulgaris, 327
Phleum, 193, 194; *alpinum*, 189, 195
Pholiota, 60
Photinia integrifolia, 473
Phragmidium fragariastri, 334; *tuberculatum*, 334; *violaceum*, 334
Phyllactinia corylea, 212
Phyllitis, 89
Physocarpus, 471; *opulifolia*, 471, 473
Physoderma, 498; *maculare*, 498, 499
Phytophthora, 299, 303, 304, 305; *cactorum*, 304; *erythroseptica*, 304; *macrospora*, 303, 305
Picea glauca, 123; *mariana*, 123
Picnomon acarna, 328
Pilobolus, 513
Pinus banksiana, 124, 516; *sylvestris*, 174
Pistacia vera, 338, 339
Pisum sativum, 326, 385
Pityrosporum ovale, 61
Plagiothecium denticulatum, 267, 268, 269
Plasmopara viticola, 326
Platanus occidentalis, 100, 266, 270
Platygloea, 33; subvestita, 33, 34, 35, 37; *vestita*, 33, 35
Plectospira, Two new species of, 385
Plectospira **agama**, **386**, 387, 388, 389, 391, 393; **plagiocaula**, 392, **393**, 394, **395**, 396, 397, 398, 399; *gemmifera*, 386, 387, 391, 396; *myriandra*, 386, 387, 396, 399
Pleospora herbarum, 340
Pleurotaenium, 247, 261; *coronatum*, 261; *trabecula*, 261; *truncatum* var. *Farquharsonii*, 253, 261
Pluchea camphorata, 100
Poa badensis, 169, 170; *nemoralis*, 333
Podospernum canum, 333
Pogonatum gracile, 267, 268, 269
Pogonia ophioglossoides, 515
Polygonum aviculare, 327; *scandens*, 161
Polypogon, 193, 194
Polyporus, 40, 43, 44, 60, 62; *abietinus*, 46, 47; *anceps*, 46, 47; *berkeleyi*, 46, 47, 52, 55, 56, 61, 62; *borealis*, 46, 47, 52, 58, 59; *cinnabarinus*, 46, 47; *croseus*, 46, 47, 52; *delectans*, 46, 47; *dichrous*, 46, 47; *distortus*, 46, 47, 49; *durescens*, 46, 47; *frondosus*, 46, 47, 52, 54, 56, 61, 62; *fumosus*, 46, 47, 52; *giganteus*, 46, 47, 52; *gilvus*, 46, 47, 52; *graveolens*, 46, 47; *guttalatus*, 45, 46, 47, 52, 58, 59, 60, 61; *hydnans*, 46, 47; *immitus*, 45, 46, 47, 56, 57, 61, 62, 63; *lucidus*, 46, 47; *obtusus*, 46, 47; *oregonensis*, 46, 47; *osseus*, 46, 47; *paragamenus*, 46, 47, 49, 52; *pubescens*, 45, 46, 47; *resinosus*, 46, 47; *schweinitzii*, 45, 46, 47, 51, 52, 54, 57, 58, 61, 62, 63; *spumens*, 46, 47; *spumens* var. *malicola*, 46, 47; *squamosus*, 46, 47; *tenuis*, 46, 47; *texanus*, 43, 46, 47, 49, 50, 52, 58, 60, 61; *trabeus*, 46, 47; *tulipiferae*, 46, 47, 56, 58, 61; *velutinus*, 45, 46, 47, 49; *vulpinus*, 46, 47, 52, 58, 59
Polytrichum ohioense, 268, 269
Populus deltoides, 366; *nigra*, 335
Poria, 60
Portulaca oleracea, 325
Potentilla, 463; *anserina*, 473; *arguta*, 516; *micrantha*, 334; *recta*, 473
Poterium canadense, 473; *sanguisorba*, 473
PROSKAUER, JOHANNES: Studies on Anthocerotales. IV, 65
Proteus vulgaris, 296
Protodontia uda, 35
Protosiphon, 311
Prunellae vulgaris, 387
Prunus, 457, 463, 469, 470, 471, 473, 474, 475; *acida*, 469; *amygdalus*, 326, 333, 470; *avium*, 470, 473; *cerasifera*, 469; *cerasus*, 457, 468, 469, 473; *domestica*, 333, 457, 469, 470, 471, 474; *institia*, 469; *maritima*, 100; *padus*, 473; *paniculata*, 474, 476; *persica*, 333, 470, 473, 476; *virginiana*, 126
Prunus domestica, Developmental anatomy of the fruit of, 457
Psalliota, 60
Psamma arenaria, 161
Pseudowintera axillaris, 366
Psilurus aristatus, 330; *incurvus*, 330
Pteris Lidgatei, 87, 92
Ptychogaster, 60
Puccinia acarnae, 328; *allii*, 329; *anomala*, 332; *antirrhini*, 329; *arenariae*, 329; *asphodeli*, 330; *baudysii*, 330; *bromina*, 330; *bupleuri*, 330; *carduipycnocephali*, 330; *cirsii*, 328, 330; *coronata*, 330; *dispersa*, 330; *eryngii*, 330; *festucinae*, 333; *fragosoi*, 330; *glumarum*, 331, 332; *graminis*, 331, 332; *helianthi*, 331; *hordei*, 332; *hordei-murini*, 332; *koele-*

riae, 330, 331; *laguri*, 332; *malvacearum*, 332; *maydis*, 334; *menthae*, 333; *poarum*, 333; *podophylli*, 329; *podospermii*, 333; *pruni-spinosae*, 333; *pulverulenta*, 333; *rubigo-vera*, 333; *scillae-rubrae*, 333; *simplex*, 332; *sorghi*, 334; *suaveolens*, 334; *triticina*, 334; *violae*, 334
Purshia tridentata, 473
Pyronema confluens, 1, 14
Pyrus arbutifolia, 473; *communis*, 328; *malus*, 473
Pythium, 386
Quamoclit, 517
Quercus, 317; *alba*, 266, 270, 367; *amygdalifolia*, 320; *carlesii*, 317, 318, 319; *cornea* var. *konishii*, 321, 322; *cuspidata*, 318; *dodonaeifolia*, 320; *formosana*, 320; *glabra*, 320, 321; *glauca*, 323; *heterophylla*, 100; *hypophyaea*, 321; *junghuhnii*, 318, 319; *kodaihoensis*, 321; *longicaudata*, 319; *pachyloma*, 324; *palustris*, 100; *prinus*, 266, 267, 270; *pseudomyrsinaefolia*, 323; *randaiensis*, 322; *rhombocarpa*, 322; *rubra*, 266, 270; *rudkini*, 100; *sasakii*, 323; *semicarpifolia*, 323; *semicarpifolia* var. *glabra*, 323; *sieboldiana*, 320; *spinosa* var. *miyabei*, 323; *stenophylla* var. *stenophylloides*, 324; *stenophylloides*, 324; *stipitata*, 318, 319; *taichuensis*, 323; *taitoensis*, 320; *thalassica*, 320, 321; *tomentosicupula*, 324; *velutina*, 266, 270; *uraiana*, 322
Quillaja, 471
Racemose Vaucheriae with inclined or pendent oogonia, 478
RAGAB, M. A.: Hyphal systems of *Auriscalpium vulgare*, 21
Ranunculaceae, 476
Ranunculus, 472; *aquatilis*, 66
Raphanus sativus, 385
Reciprocal tomato-tobacco grafts, The growth of, 26
REEDER, JOHN R.: Affinities of the grass genus *Beckmannia* Host., 187
REUSZER, H. W. (Review), 429
Rhamnus alnifolia, 126
Rhizoclonium **giganteum, 343,** 345; *hieroglyphicum*, 343
Rhizoctonia bataticola, 335
Rhizopogon, 60
Rhododendron lapponicum, 516
Rhoeo, 134; *discolor*, 167, 168
Ribes, 267, 469; *americanum*, 126; *triste*, 126
Riccardia pinguis, 67
RICKETT, H. W. (Reviews), 140, 232, 517
RILEY, PARKES H. & CHESTER, C. IRVIN: Duration of the stages of microsporogenesis in *Gasteria*, 273
Rosaceae, 460, 466, 472, 474, 475
Rosa micrantha, 334
Rubus, 267; *hispidus*, 473; *Idaeus*, 473; *pubescens*, 126, 128; *ulmifolius* subsp. *anatolicus*, 334
Rumex acetosa, 170; *acetosella*, 395
Sabatia angularis, 99; *stellaris*, 100
Saccharomyces, 197, 199; *carlsbergensis*, 197, 198, 199, 200, 201, 202, 203; *cerevisiae*, 197, 198, 199, 201, 202, 203; *ellipsoideus*, 197; *logos*, 203
Saccharomyces, Biochemical investigation in, 197
Saccharum officinarum, 386
Saccobolus, 2
Salix, 378; *nigra*, 366; *pyrifolia*, 516
Sambucus, 469
SANWAL, B. D.: The development of the basidium in *Coleosporium sidae*, 205
Sarracenia, 515
Sassafras albidum, 267
Schaffneria nigripes, 92
Schedonnardus paniculatus, 190, 195
Schismocarpus, 138; **matudai, 138;** *pachypus*, 138
Schismocarpus, A second species of, 138
Schizandra, 374, 375; *glabra*, 366
Schizophyllum, 60
Sciadopitys, 417
Sclerolepis uniflora, 99
Scytomonas **ovatum, 345, 348; stene, 345, 348**
Sclerophthora, 304; macrospora, 304, 305, 306
Sclerospora, 299, 300, 303, 304, 305, 306; *graminicola*, 299, 304, 306; *kriegeriana*, 305; *macrospora*, 299, 300, 303, 304, 305; *oryzae*, 305
Secale cereale, 330, 331
Sedum, 217; *purpureum*, 169
Seismosarca, 35
Sempervivum soboliferum, 169
Senecio, 406
Septoria apii-graveolentis, 336; *nodorum*, 336
Sequoia, 409; *sempervirens*, 409, 411
Setaria, 299; *italica*, 189, 195; *viridis*, 305, 385
SHARP, AARON J. (Review), 233
Shiia, 318; *carlesii*, 319; *longicaudata*, 318, 319; *stipitata*, 319; *uraiana*, 322
Sida, 205
Silene spinescens, 327

SILVA, HERMAN: Fifteen new algae, 342
Sinningia purpurea, 173
Sisymbrium irio, 325, 326
SMALL, JOHN A. (Reviews), 341, 431, 517
Smilacina stellata, 100; *trifolia*, 516
Smilax rotundifolia, 267
Smuts reported from the United States, Notes on two, 498
Solanum melongena, 337, 340, 386, 453, 456; *nigram gigas*, 134
Sorbaria sorbifolia, 473
Sorbus, 471; *hybrida*, 471, 473; *torminalis*, 473
Sorghum, 335; *vulgare*, 189, 195
Spartina, 99, 100
Spegazzinia, 155, 156, 157, 160, 161, 163; *ammophila*, 155, 161; *brasiliensis*, 155, 159, 162, 164; *calyptrospora*, 155, 158, 161; *chandleri*, 155, 160, 164; *coffeae*, 155, 160, 163; *effusa*, 155, 161; *lobata*, 155, 161; *meliolae*, 155, 159, 162, 163; *meliolicola*, 155, 159, 163; *ornata*, 155, 156, 157, 159, 162, 164; *rubra*, 155, 161; *tessarthra*, 155, 157, 159, 160, 161, 162; *trichophila*, 155, 157, 158, 159, 160, 163; *tucumanensis*, 155, 159, 162
Spegazzinia Sacc. and *Isthmospora* Stevens, Notes on the hyphomycetous genera, 155
SPERRY, JOHN J.: Note on the flora of South-Central Texas, 350
Sphacelotheca schweinfurthiana, 335
Sphaerocarpos, 98
Sphagnum, 126, 128
Spinacia oleracea, 385
Spiraea, 471, 473; *ulmifolia*, 473
Spiranthes cernua, 143; *praecox*, 99, 143
Sporangial phase of downy mildew on *Eleusine coracana*, 299
Sporidesmium, 161; *tessarthrum*, 156, 157, 159, 162
Spumatoria, 513
Staphylea trifolia, 143
STARR, RICHARD C.: Morphology and reproduction of *Characium saccatum*, 308
Staurastrum, 260; *Dickiei* var. *parallelum*, 261
Stellaria araminea, 329
Stemphylium botryosum, 338, 339, 340; *muriculatum*, 160, 163
Stephanandra, 471, 473; *flexuosa*, 437; *incisa*, 471, 473
Stereum, 60
STERLING, CLARENCE: Developmental anatomy of the fruit of *Prunus domestica* L., 457
STEYERMARK, JULIAN A.: A second species of Schismocarpus, 138; A new *Meliosma* from the Colombian Andes, 500
Stipa viridula, 385
Streptomyces, 509
Strophanthus, 413, 414; **glabriflorus, 412,** 413, 414; *laurifolius*, 412; *pendulus*, 413; *ogovensis*, 413; *petersianus* var. *grandiflorus*, 413; *paroissei*, 413; *punctiferus*, 413; *sarmentosus*, 412, 413, 414; *sarmentosus* var. *major*, 413; *sarmentosus* var. *pubescens*, 413; *sarmentosus* var. *verrucosus*, 413; *senegambiae*, 413
Stropharia, 60
Subbaromyces, 511, 513, 514; **splendens,** 510, **511,** 514
Synaedrys amygdalifolia, 320; *carlesii*, 319; *formosana*, 320; *formosana* var. *dodonacifolia*, 320; *kodaihoensis*, 321; *konishii*, 321; *rhombocarpa*, 322; *rhombocarpa* forma *suishaensis*, 322; *stipitata*, 318, 319; *taitoensis*, 320
Syringa vulgaris, 169, 170, 172
Talauma, 349, 350; *candolleri*, 349; *mexicana*, 366
Taphrina deformans, 326
Taxodium, 415; *ascendens*, 415, 416, 417; *distichum*, 415, 416, 417; *distichum* var. *imbricarium*, 416; *mucronatum*, 415, 416, 417
Taxodium, Three species of, 415
Tetrachia, 159; *quadrigemina*, 157, 159, 162; *singularis*, 160, 163
Tetracoccosporium, 156; *sacchari*, 164
Tetrahymena pyriformis, 419
Tetraploid smooth bromegrass, 131
Teucrium montanum, 170
Thalictrum, 136, 333; **cardenasianum, 136;** *dioicum*, 126, 128; *innucans*, 136; *venturii*, 136
Thecopsora vacciniorum, 335
THIRUMALACHAR, M. J., C. G. SHAW & M. J. NARASIMHAN: Sporangial phase of *Sclerospora* and identity of *Sclerospora macrospora*, 299
Thuidium delicatulum, 126, 128, 267, 268, 269
Thymus serphyllum, 169, 170
Tilletia, 498, 499; *euphorbiae*, 499
Tilletiaceae, 499
Titae costaricana, 160
Tomato-tobacco grafts, The growth of, 26
Torreya, 95, 139, 225, 349, 424, 515
Trachelomonas, 178; *ensifera* var. **depressa, 345, 346;** *ensifera* var. **spikata,** 346
Tradescantia, 273, 274, 277, 278, 445, 452,

453, 455; *ozarkana*, 452, 456; *paludosa*, 274, 445, 446, 452, 454, 455; *subaspera*, 453; *virginica*, 452, 453, 455
Trametes, 60
Tranzschelia punctata, 333
Tremella, 213, 214
Tremellales from the Southern Appalachians, New or noteworthy species of, 33
Trichoderma viride, 337
Tricholoma, 60
Trickling filter fungi, Study of, 507
Trifolium campestre, 328; *scabrum*, 328
Trillium erectum, 134; *ovatum*, 134; *sessile*, 134
Triposporium cristatum, 159, 160, 162
Trisetum sesquiflorum, 331
Triticum vulgare, 326, 331, 334, 335, 336
Tubularia, 60
Tulasnella violea, 40
Ulothrix **Dotyi**, 344, 348
Umbelliferae, 351
Uredo Fici, 327
Uromyces appendiculatus, 327; *armeriae*, 327; *fabae*, 327; *heliotropi*, 327 *inaequialtus*, 327; *limonii*, 327; *pisi*, 327; *polygoni*, 327; *renovatus*, 327; *striatus*, 328; *trifolii*, 328
Ustilago, 498; *alismatis*, 498, 499; *avenae*, 335; *bromivora*, 335; *bullata*, 335; *cynodontis*, 335; *maydis*, 335; *tritici*, 335
Vaccinium, 143, 469; *myrtillus*, 335
Vaucheria, 478, 481, 482, 485, 495, 497; *adunca*, 481, 494, 495, 496; **alaskana**, 481, 484, **494**, 496; *amphibia*, 496; arrhyncha, 479, 481, 482; *brevicaulis*, 481, 492, 496; *coronata*, 486; *geminata*, 478, 483, 485, 492, 493; *geminata* var. *racemosa*, 485, 493; *hamata*, 478, 481, 483, 485, 486, 487, 488, 489, 490, 491, 493, 494, 496, 495; *hamulata*, 479, 480, 482, 492; **longata**, 478, **481**, 484, **492**, 493, 496; *orientalis*, 495, 496; *pendula*, 490; *pseudo-geminata*, 481, 494, 495, 496; *pseudo-monoica*, 495, 496; *sacculifera*, 479, 482; *scrobiculata*, 496; *terrestris*, 478, 480, 481, 482, 485, 486, 487, 490, 491, 494, 495, 496; *uncinata*, 478, 479, 480, 481, 482, 483, 496; *undulata*, 481, 484, 493, 496; *walzi*, 481, 483, 484, 485, 490, 496; *woroniniana*, 493
Vaucheriaceae, 497
Vaucheriopsis, 478, 481; *arrhyncha*, 479; *sinensis*, 479
Vauquelinia corymbosa, 473
Vegetation of a raised bog, 123
Viburnum, acerifolium, 267, 270
Vicia, 385; *faba*, 505; *macrocarpa*, 327
Vinca rosea, 223
Viola, 334; *fimbriatula*, 99; *pallens*, 126; *pedata*, 99; *primulifolia*, 99; *tricolor*, 385
Vitis, 267; *vinifera*, 326
WAGNER, WARREN H., JR.: *Asplenium* prototype of the genus *Diellia*, 76
Waldsteinia fragarioides, 473; *geoides*, 473
WALKER, E. H. (Review), 233
WHALEY, W. GORDON: The growth of reciprocal tomato-tobacco graft, 26
WHERRY, EDGAR T. (Review), 228
WHITEHEAD, MARVIN D. & M. J. THIRUMALACHAR: Notes on two smuts reported from the United States, 498
Winteraceae, 475
WODEHOUSE, ROGER, P. (Review), 429
WOOD, JOHN L.: Ascus development in *Ascobolus magnificus*, 1
Xyris fimbriata, 99
YUSEF, HASAN M.: Requirements of some Hymenomycetes for essential metabolites, 43
Zea mays, 335

The Torrey Botanical Club
announces the appearance of

MEMOIRS OF THE TORREY BOTANICAL CLUB

Volume 20 Number 3

REPRODUCTION IN PETUNIA

by

Arlow Burdette Stout

202 pages • 61 figures and charts

The culmination of many years of research upon this genus. The author has recently retired from the staff of the New York Botanical Garden.

Price $3.50

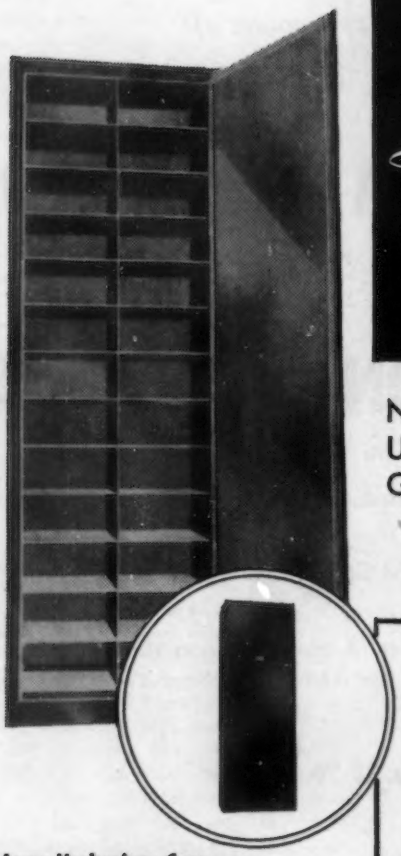
The MEMOIRS have been published since 1889 and include papers on subjects of general interest by L. H. Bailey, N. L. Britton, P. A. Rydberg, H. S. Jackson, and many others.

Most issues are still available.

Address orders and inquiries to

DR. GILY E. BARD
Hunter College
New York 21, N. Y.

MAXIMUM STORAGE



Lane Herbarium Case
The Accepted Standard for general use

Lane HERBARIUM CASES

NOW IN USE IN OVER 115 UNIVERSITIES, BOTANICAL GARDENS, NATIONAL PARKS, ETC. since their introduction!

SPECIFICATIONS

STANDARD HERBARIUM
84 1/8" High, 27-13/16" Wide, 18-25/32" Deep

JUNIOR MODEL HERBARIUM
40" High, 27-13/16" Wide, 18-25/32" Deep

SOME USERS OF LANE HERBARIUM CASES

New York Botanical Gardens
Abilene Christian College
Agricultural & Mechanical College of Texas
Duquesne University
Florida State University
Georgia Teachers College
Louisiana Polytechnic Institute
Loyola University
Oklahoma Agricultural & Mechanical College
Southern Methodist University
State College of Washington
Tulane University
University of Alabama
University of Arizona
University of Arkansas
University of Chattanooga
University of Massachusetts
University of Idaho
University of Nevada
University of Texas
University of Wisconsin
Washington University
Yale University
Grand Canyon National Park
Olympic National Park
Hawaii National Park
Glacier National Park
Canisius College
Catholic University of Washington
Carleton College
Emory University
U. S. Dept. of Agriculture
Oregon State College
Riverside Municipal Museum
Rutgers University

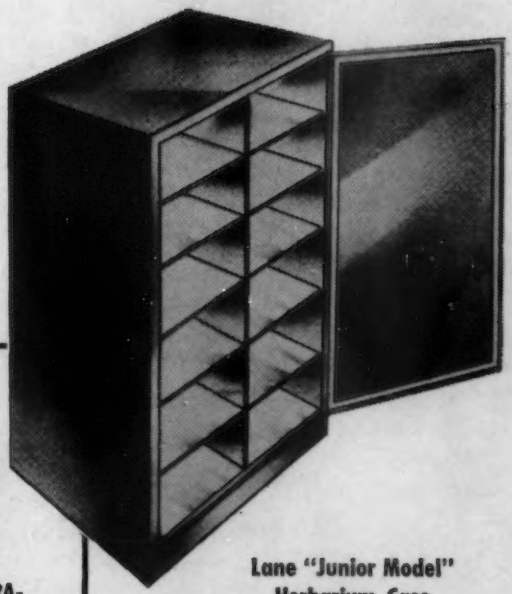
PROTECTION

JUNIOR MODEL HERBARIUM CASE

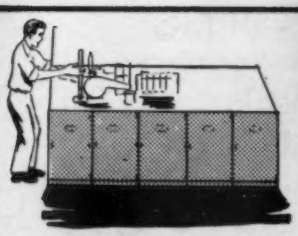
IDEAL FOR SUPPLEMENTAL USE, WORK TABLE, UNDER WINDOWS, SMALL COLLECTIONS, STUDENTS, ETC.

CHECK THESE OUTSTANDING FEATURES:

- **Air-Tight and Insect Proof Seal**
- **Standard Size Compartments**
- **Three-Point Compression Type Locking Mechanism**
- **Effective Air Circulation and Fumigation**
- **Right or Left Doors**
- **Double-Wall All-Steel Construction**



Lane "Junior Model" Herbarium Case



A WORK TABLE IN THE LABORATORY WITH LINOLEUM COVERED WORKING TOP.

ALL LANE HERBARIUM CASES ARE DELIVERED COMPLETELY ASSEMBLED AND READY FOR USE.

WRITE FOR COMPLETE DETAILS.

Institutional Division CHAS. P. Lane CORP

105 CHAMBERS STREET, NEW YORK 7, N. Y.

IF *YOU*
had to Clean the Laboratory Ware
YOU would insist on ALCONOX

No matter what you want to clean . . . glassware, metal ware, porcelain ware, machine parts . . . No matter how dirty or greasy they may be . . . ALCONOX will make them sparkle.

In hard water, soft water, hot or cold

this modern wetting agent is equally effective. It actually lifts off dirt, grime and grease faster and cleaner than anything you have ever tried.

Saves energy, Saves Time

Just wash and rinse. Practically no toweling needed. Economical, too. One spoonful makes a gallon of active cleanser ready to go to work on your toughest job.

Tested and Used

by many leading laboratories, hospitals, food and industrial plants. Test it yourself . . . on a tough job.

3-lb. box $1.95; 12-box carton $18.00
50-lb. bags @ 40¢ lb. f.o.b. New York

Order Today or Write for Free Sample

STANDARD SCIENTIFIC SUPPLY CORP.

34 West 4th Street **New York 12, N. Y.**

A CALL FOR BACK NUMBERS

of the

Bulletin of the TORREY BOTANICAL CLUB

Our stocks of the following numbers are very low, and we are completely out of a few of them:

Vol. 67 (1940), No. 6.
Vol. 68 (1941), Nos. 1, 2, 3, 4.
Vol. 70 (1943), Nos. 1, 2, 3.
Vol. 71 (1944), Nos. 1, 2.
Vol. 76 (1949), No. 1

The war has increased the demand for back numbers. If any members of the Club are willing to part with some of their back numbers the Business Manager will be very glad to receive them.

Please write to:

DR. GILY E. BARD
Hunter College
New York 21, N. Y.

Instructions for Contributors

Contributions will be received only from members of the Torrey Botanical Club.

Manuscript should be typed double-spaced on one side of standard paper. If a line of 60 characters is used and 26 lines to the page, the number of printed pages (exclusive of illustrations and bibliography) will be about half the number of typed pages. The editor may accept papers up to 16 printed pages in length. Preference will be given to shorter papers. Illustrations (including tables and graphs) should not exceed 20 per cent of the text; the authors of more copiously illustrated articles may be asked to pay for the excess.

Drawings and photographs should be mounted on stiff cardboard and the desired reduction plainly indicated. Figures should be so planned that after reduction they will occupy the entire width of a page (4⅝ inches) and any portion of the height (7⅛ inches). Labels should be parallel to the shorter dimension of the page. It is best to combine illustrations into the smallest possible number of groups. The editor cannot accept loose figures or figures so mounted as to leave large unused spaces on the printed page. The thickness of lines and dots must be planned with the desired reduction in mind; it is still more important to calculate the requisite spaces between lines and dots.

Figures should be numbered consecutively. Plates are not inserted unless special methods necessitate them. Legends for figures should be typewritten and included with the manuscript (*not* affixed to the figures). All legends for one group of figures should form a single paragraph. If magnifications are stated, they should apply to the reduced figures.

In style recent usage of the Bulletin should be followed. This applies to punctuation, capitalization, use of italic, designation of new species and combinations, citation of specimens and synonyms, and reference to literature and illustrations. References to literature are made by date. Time and errors will be saved if the usage and abbreviations of the Index to American Botanical Literature are adopted. The title of the paper should be as short as is consistent with clarity. Primary divisions may be indicated by centered headings, subdivisions by italicized captions at the margin. Except brief notes, every paper should conclude with a summary of numbered paragraphs. The institutional or other address of the author should appear beneath the summary.

Contributors may order reprints of their articles when they return galley-proof to the editor. A schedule of charges is sent with the proof, and will be supplied to prospective contributors on request.

FINE MICROSCOPE SLIDES FOR DISCRIMINATING BIOLOGISTS

TRIARCH SLIDES stress beauty as well as utility, and their freedom from artifacts aids student comprehension.

GOOD SLIDES cannot be produced cheaply, yet TRIARCH slides are moderately priced, and the catalog price includes all delivery costs to any address in the United States.

TRIARCH gives you accuracy and dependability, with rapid service.

TRIARCH CATALOG NO. 10, with many new full-page photomicrographs, is now being distributed. Both plant and animal slides are listed.

For Catalogs, write to:

TRIARCH PRODUCTS

GEO. H. CONANT

RIPON, WISCONSIN